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OPERATIONALLY RESPONSIVE SPACE: CREATING RESPONSIVE SPACE FOR AMERICA

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13. ABSTRACT (maximum 200 words)

Tactical space support has earned a reputation as unresponsive and the Operationally Responsive Space Office was created in 2007 to address this for the military. The intent of this course project is to use an educational research approach to develop a future architecture that will make space responsive in 2025. This paper evaluates the shortcomings that hinder quick and effective space-based support to the U.S. Military and Intelligence Community. The current space community is fragmented; preventing quick, unified decisions, and does not have the executive clout necessary to lead effectively. Our group's solution creates a Department of Space at the cabinet level. The Department of Space will unify the space community, promoting quicker decisions with one common and consistent vision. This change would enable unified plans and policies as well as allow one organization to prioritize all of the space programs. The responsive culture would facilitate other needed changes to Space Operations, Launch and Acquisition.

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PREFACE

SS4051 is the second course of a two course sequence which comprises the capstone project for the Space Systems Operations program at NPS. SS3041, the initial course, teaches the students the architectural design process – from generating basic requirements through conceiving of and evaluating alternative solutions and ultimately selecting the preferred approach. During SS3041, the students are presented a project – derived from current challenging and relevant efforts in the National Security Space area – and their primary "deliverable" at the completion of the class is a set of requirements for the assigned architecture to satisfy.

For the FY2008 effort, Operationally Responsive Space (ORS) was selected as the topic of study. In SS3041, the students defined what ORS "should be," and described the characteristics and capabilities of an ORS architecture. In SS4051, the students took these definitions and capabilities and generated alternative approaches to satisfying them. This report describes the result of that effort.

For FY2008, there were two in-residence teams of 10 students, and a single distance-learning team of 7 students. While most of the in-residence students had no space-related experience other than their time in the Space Systems Program at NPS, the majority of the distance-learning students had worked in or were currently working in space-related jobs.

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EXECUTIVE SUMMARY

Our group of 10 NPS Space Systems Operations Students was tasked to develop a space architecture that would be “responsive” by 2025. We were given the responsibility to determine what Operationally Responsive Space (ORS) meant and how to get there.

The key to being responsive and reacting quickly is adapting our culture to fit that mindset. Responsiveness as a mindset requires a complete shift in philosophy from our current risk-averse culture. This shift in philosophy will require a complete overhaul of the National Security Space Enterprise (NSSE) to a one-leader structure. That structure is the Department of Space.

The current NSSE has fragmented leadership that is counterproductive to being responsive, let alone to developing a culture of responsiveness. Unity of command will ensure that there is no ambiguity of responsibility or direction. As we stand up the Department of Space, streamline its functions and instill a responsive mindset, we will need one leader.

The Department of Space is inevitable as we rely more and more on that medium to conduct business, travel and warfare. Communications, navigation, early warning systems and space exploration are being joined by the budding space tourism business as how we use space. Managing all these facets will require one funding source and the clout of a cabinet level leader. We will eventually have to enact this change. While creating the Department of Space now would be extremely difficult, pushing it off until later will be even more difficult and the opportunity cost would be even greater.

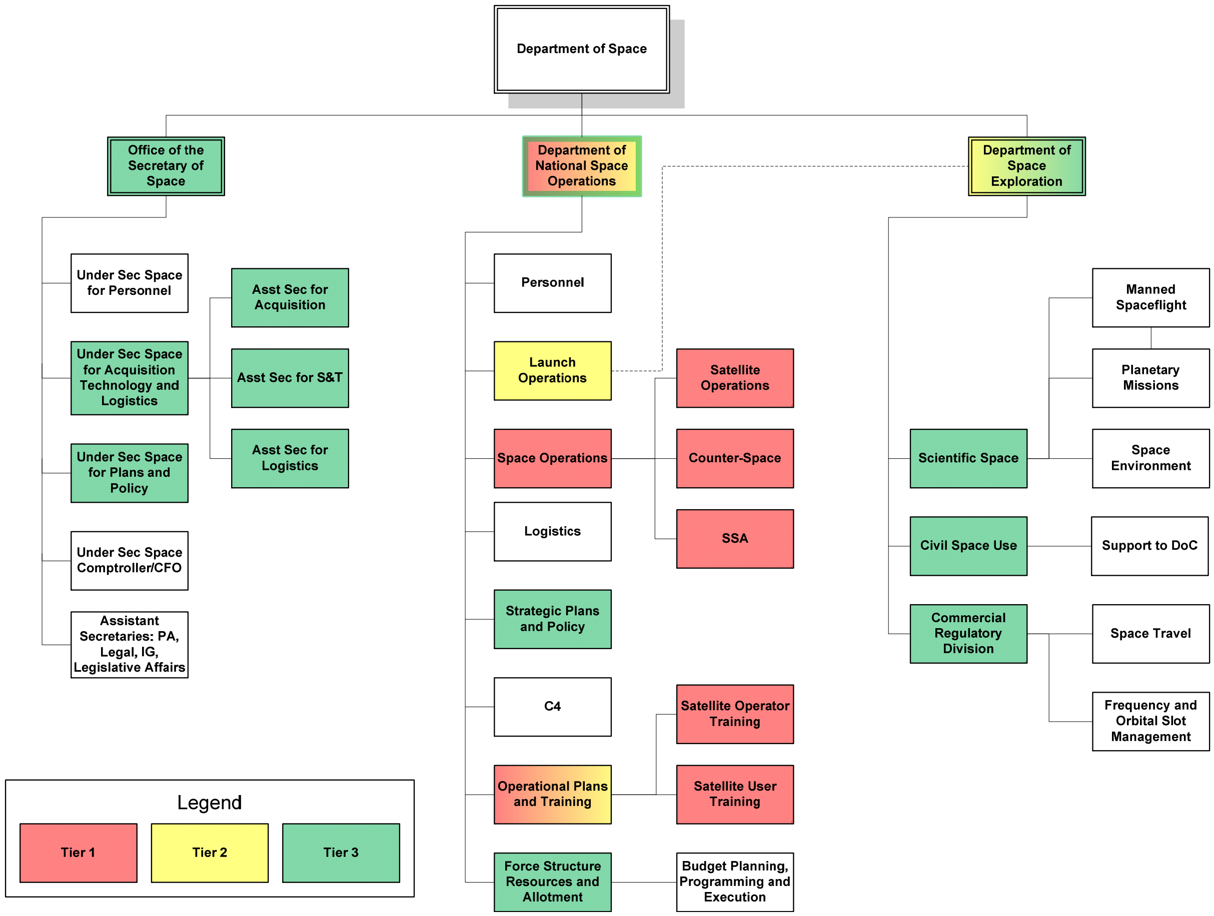

Figure 1 Organizational Structure of the Department of Space

The most important way to make the business of space responsive is to build that into the thought process of everyone in that organization. If we indoctrinate people at every level towards the importance of responsiveness, they will develop their own solutions and implement them far more effectively than if we mandate them to work more quickly and micromanage each change. With responsiveness as our organization mindset, the goal will be clear and results will follow.

Part of a responsive mindset is training people to operate in a denied environment. Training will reduce the impact of losing space assets. With our warfighters capable of

navigating and fighting with diminished GPS accuracy and reduced SATCOM, we are less vulnerable to our "Space Achilles Heel" (Crosier 19).

Another key to being responsive is having survivable assets in orbit as well as on the ground. Through Space Situational Awareness (SSA), Offensive Counter Space (OCS) and Defensive Counter Space (DCS), we prevent our assets from being rendered ineffective. There is nothing more responsive to attack than spoiling that attack.

Policies that enable responsive space will be enforced industry wide and perpetuate responsiveness. With one leader laying down the vision, the space industry can move forward in a responsive direction. The following policies will make space more responsive:

- Mandatory spares for critical satellites will be made policy
- Spare launch pads, launch vehicles and launch facilities will be required for certain missions
- A common bus standard will be made available

Fast technology integration is a key ingredient to being responsive. We must be able to identify our shortcomings and quickly integrate new technologies to solve those problems.

Acquisition is an important part of being responsive, and has had a history of being unresponsive. In order to be more responsive to programs most critical to national importance, the acquisition system will have a method in place to rapidly complete critical projects.

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I. EVOLUTION OF ORSB

In the winter quarter, in SS3041, our group determined WHAT Operationally Responsive Space is to us. We decided the NSSE needed three offices to help focus its efforts in providing responsive space to the warfighter and the intelligence community. The three offices were the Knowledge Center, the Launch Support Division and the Space Center of Excellence. We broke down the responsibility of each office by functions and applied the missions from JP 3-14. We decided to group the responses by temporal means as well, which we called the Response Tiers. Tier 1 is comprised of responses that take from minutes to days to take effect. Tier 2 responses take weeks to months. Tier 3 responses take months to years. The three tiers were complemented by the three functional divisions:

- Knowledge Center (KC)
- Launch Support Division (LSD)
- Space Center of Excellence (SCOE)

To clarify, Knowledge Center dealt mostly with tier one responses, but was not limited to that role. Likewise Launch Support Division and Space Center of Excellence were nebulously tied to tier two and tier three responses respectively. Our definition of Operationally Responsive Space:

> *Provide on-order, space-based capacity to DoD/IC users in order to resolve identified urgent gaps during national or operational crisis using current technologies, utilizing the ORS Knowledge Center, Launch Support Division, and Space Center of Excellence.*

Beginning this quarter, we had to develop HOW we were going to make space responsive. Initially we decided to continue the same path our group started in SS3041. We started with the same definition, and we expanded our assumptions. In order to provide responsive space in 2025 certain assumptions had to be made. Although we never changed the

content, we ultimately changed the title. The assumptions became known as “Our Vision.” This is the vision that would enable a responsive environment:

- Robust Offensive/Defensive Counter Space & SSA; US response limits losses to enemy action
- Global Information Grid (GIG) in space
- Satellites hardened against Electromagnetic Pulse (EMP)/laser
- IMINT/SIGINT systems healthy and capability has evolved
- Robust and redundant Comm/PNT/ISR/Wx constellations exist
- Commercial Systems augment National Systems and capability matches (current) DoD/IC
- High Altitude Long Loiter (HALL) airships and Unmanned Aerial System (UAS) provide most <u>theater</u> ISR
- Forces train as if in denied environment
- Department of Space provides capability/services/capacity NOT analysis or intelligence products

We started by designating roles for everyone in the group. We first decided on a Program Manager: Maj Brian Anderson and his assistant LT Alex Bein. We divided the rest of the group into three teams. The Knowledge Center was led by LT Phil Smith with LCDR Sam Messer and LCDR Greg Fitzgearld on his team. The Launch Support Division was led by Maj Gerry Gleckel with Maj Corey Collier and LT Rich Arledge on his team. The Space Center of Excellence was led by LT Matt Crook with MAJ Alex Braszko on his team.

Knowing WHAT we wanted ORS to be, we began focusing on HOW we wanted to get there. Each team was responsible for determining their role in making space responsible. The Knowledge Center focused on ways to disseminate information and train space customers so they would be prepared for any loss of capability. Launch Support Division focused on ways to speed up the launch process. The Space Center of Excellence focused on acquisition, plans and policy as well as technology development and integration.

In our first iteration, we decided not to focus on the four space missions from JP 3-14, because they were enveloped by our three output tiers. The three tiers:

- Tier 1 is an immediate response taking minutes to days.
- Tier 2 is a mid term response taking weeks to months
- Tier 3 is a long term response taking months to years

In our second iteration, we eliminated the Knowledge Center, Launch Support Division and Space Center of Excellence as separate organizations and focused more on the tier functions. We eliminated these offices to avoid inserting more bureaucracy into the system; using the tiers to organize our efforts allowed us to use existing infrastructure. This led us to adopt a new, more concise ORS definition:

Provide threat-resistant space capacity to support DoD/IC users in a timely fashion.

As we progressed, we realized that ORS requires a culture of responsiveness. In order to have the authority to develop and enforce a culture across the entire NSSE we would need one leader. We decided there is a need for that leader to be at the cabinet level. A leader with such a high position is needed because space transcends the military, the intelligence community and commerce to merit is own cabinet level department, The Department of Space. Once stood up, the Department of Space will be able to affect many changes that were unlikely without it. In order to quantify the effects of the changes, we developed a Measure of Effectiveness (MoE) for each one.

The next three sections will focus on the development of each of the three tiers.

A. DEVELOPMENT OF TIER 1

The Knowledge Center, renamed ORS OPS very early in the quarter, was designed to satisfy most tier one needs. It was designed to be an all encompassing operations center to handle emerging space crises, to promulgate situational awareness and to train end users.

The struggle with the ORS OPS is how we can accommodate users in a quicker fashion than already exhibited. We decided to offer twenty-four hour support in the fashion of a call center, a chat line and RSS feed. The ORS OPS was also designed to inspect each of the end users for proficiency. The constructive feedback we received from our professors was "this path was too far into the weeds and did not did not solve the larger scope of the problem."

After regrouping we decided to attack the problems more directly, and to go directly after the Tiers they most resembled. ORS OPS converted most directly to Tier 1. Tier 1 is an immediate response gauged in minutes to days. We focused on those capabilities that would allow us to be responsive in minutes to days:

- Augment or replace capacity/capability
- Warfighter must train in a denied environment
- Maintain Space Operational and Situational Awareness

We decided to concentrate on Space Operational and Situational Awareness. In order to protect our space assets we would need to know when they are in danger. This would require a complete network that could monitor the entire orbit. Once we know where and when the threats are, we need a way to thwart them. Without going too far into the weeds we discussed decoys, maneuver, and focused projectiles from the satellite being attacked. This established Offensive Counter Space and Defensive Counter Space as important divisions under the Operations Department. Even if we cannot react to prevent the loss of the satellite, we can mitigate its effects by augmenting or replacing that capability quicker.

Critical satellites need to be hardened against attack and the space environment. Satellites most important to national defense need to be resistant to solar flares and EMP. They must also be hardened to defeat lasers and jamming. Our satellites are big targets to our adversaries, and we must reduce their vulnerability.

We also focused on data management. Every user will have communication with the Operation Centers via the Space Operations Command Center. The operation center will have communication with every ground station via the managers for that functional intelligence collection area (i.e. ELINT, SIGINT, IMINT). Ground stations will have communication with a specific satellite with the potential to be a back-up for other platforms with configurable software with well-defined interfaces.

Tier 1 will be enforcing the training of end users to operate with and without space assets and satellite operators to react to rapid tasking or emergencies. Training the end users to operate without space assets minimizes the effects in the case of an actual loss of space assets. Training the operators ensures pre-planned responses (PPRs) can be quickly executed with maximum effect.

B. DEVELOPMENT OF TIER 2

The Launch Support Division was set up to organize launch to maximize its responsiveness. In the current system there are many potential bottlenecks that can hold up a launch. We looked for ways to eliminate those bottlenecks. Then we decided which methods were most responsive and cost effective.

Launch looked at four areas that are most likely to impact the timeliness and responsiveness of launch:

- Payload

- Launch facility
- Launch vehicle
- Integration and testing

For the payload, we looked at keeping spares of each satellite type on the ground ready for launch, we considered a new acquisition process for each new satellite, and we considered having a common bus for all satellites for quicker integration.

To alleviate some of the bottlenecks and improve responsiveness at our launch facilities we considered a variety of options. We recognized the disparity of organizations and management at the current launch sites and considered unifying all launch facilities under one command. In order to expand our possible volume of launches and develop redundant facilities, we looked at building more launch pads at the existing Federal and commercial spaceports as well as building new sites from scratch. We examined allocating sites by orbit and mission type. We also looked at the idea of keeping pads reserved for emergency high priority launches. Lastly, we thought of increasing our launch bases physical security with air patrols and missile defense.

We recognized that while the launch vehicles themselves are not unresponsive, their availability may be. To make them more responsive we considered the possibility of storing extra launch vehicles at the launch bases. We could also maintain a higher level of readiness on our launch vehicles. We could also invest money into cheaper and better launch technologies, ultimately leading to improved launch vehicles.

To make integration and testing more responsive we looked at having more facilities at launch bases and designing satellite processing for a quicker integration. We also looked at how satellites are processed today and considered how crews are managed.

After our next iteration we dropped the name Launch Support Division and called it Tier 2 to be consistent with the rest of the groups. We still decided to focus heavily on the launch portion of the process, since that is an area that could use a lot more responsiveness. We evaluated a variety of responsive enabling options for the following Tier 2 functions:

- Satellite availability
- Facilities – processing and pads
- Launch vehicle availability
- Integration and test timelines

With some preliminary decisions, we ruled out some of the less responsive options. We decided to further evaluate: spares, building more launch facilities at existing launch bases, causes for launch delays. The next step was to estimate the cost of making them more responsive. The cost of building additional spares would vary by satellite program. Based on recent Evolved Expendable Launch Vehicle (EELV) pad renovations, we estimated the cost of adding an additional flexible launch facility at around $500 million.

To be more responsive we need to reduce launch delays. Over the last several years there were a wide variety of causes for launch delays. Cost, software problems, hardware problems, abnormal tests and even debris from ASATs have caused delays in U.S. based launches. We decided that there was little we could do to eliminate launch delays, but by being flexible, we could limit the impact felt on further down the line. For the final iteration we re-evaluated all of the ideas that can make space more responsive:

- Having a centralized launch site authority
- Enforcing mandatory spares for critical satellites
- Enforcing mandatory spares for launch vehicles
- Providing a common bus for testing, development and science.
- Enforcing a regular launch schedule
- Adding more flexible launch pads and facilities
- Better accounting for launch reimbursement

- Cross train the launch and processing crews
- Less testing at launch bases
- Provide emergency launch for manned spaceflight recovery

Implemented in coordination with the Department of Space and the responsive culture, each of these changes will make space more responsive. We will expand upon each of these changes in the Tier 2 section of the paper.

C. DEVELOPMENT OF TIER 3

From a Tier 3 perspective, our group began this quarter with an organization we created last quarter to encompass months-to-years ORS requirements: the Space Center of Excellence. We concluded last quarter that future space technology initiatives needed to be integrated into existing 2025 architectures, but that the current process of integration and technology insertion is essentially undefined and certainly not efficient. We decided that the SCOE, the ORS office's primary link to Tier 3, should act as a "gatekeeper" of new technology initiatives. The SCOE would also have a close relationship with the other Tier offices or divisions within ORS, including the Launch Support Division and the Knowledge Center. Thus, we had an organizational framework for the ORS office which included sub-organizations focused on specific temporal tiers, the SCOE's being months-to-years.

We dove into this quarter's project by expounding upon what we envisioned the SCOE should become, focusing more on the organizational aspects and constructs than its functions. We eventually realized a better approach would be to first refine those functions and work on the physical location, composition and disposition of the organization later. Halfway through the new quarter, we also changed our focus from the SCOE office construct to Tier 3 functions. However, we began with an understanding that the SCOE needed to act as a gatekeeper for space technologies and should determine what programs were ORS specific.

As we progressed, we realized that ORS is more of a culture or mindset rather than a specific program or office. Still, our definition of the roles and functions of the SCOE continued to morph. We decided that the SCOE should not act solely as a gatekeeper of ORS relevant space technologies, but that it should also actively seek out new responsive space technologies. We developed a Find, Filter and Forecast model to best describe the SCOE's primary tasks. We also came up with several options of how the SCOE should be modeled, looking to DARPA and NASA as examples. We even considered specific locations within the continental US to locate the office.

The office would seek out and find new and relevant responsive space technologies. It would act as a gatekeeper and filter out those technologies by creating and advocating responsive space compatibility standards. Finally, the SCOE would attempt to forecast future responsive space technologies and direct newly discovered technologies not related to ORS to the correct office or agency. Essentially, we bit off more than we could chew by trying to shepherd, with one small office or organization, the entire space community into developing ORS applicable programs and then attempting to develop the standards and requirements for what constituted operationally responsive space. We began to realize the model of a small office taking on such large responsibilities did not seem very realistic.

As our group progressed with feedback from periodic project reviews, our initial approach seemed more and more improbable. With the decision to move to a temporal focus rather than an office construct or model, our needs became clearer. With the idea of the creation of a Department of Space and new assumptions for the 2025 timeframe, our vision for Tier 3 became even more refined.

Tier 3 within the Department of Space would focus on space plans and policy functions, acquisition functions and science and technology/research and development (S&T/R&D) functions, all allowing to more responsiveness within the National Security Space Enterprise. We chose not to pursue the office construct of the SCOE and did away with the name entirely. We determined that Tier 3 would not exist as simply another bureaucratic middleman but would serve as an enforcer of responsive-oriented strategic plans and policies, an integrator of current acquisition processes and future acquisition programs, as well as an enabler of current and future S&T/R&D initiatives. To execute these tasks effectively would no longer require a large, heavily manned organization or office but would rather simply require the authority derived from the creation of a Department of Space.

II. MEASURES OF EFFECTIVENESS

In order to properly assess each of our changes we have come up with a system to measure their effectiveness. We are using the Measures of Effectiveness described by James Wertz in his paper presented at the responsive space conference in Los Angeles on 28 April 2008. The MoEs we used allowed us to give each course of action a measure of utility. Our objective was to prioritize the MoEs by how useful they are to the warfighter and intelligence community. It is hard to quantify intangible effects like risk, flexibility, level of preparedness and measure of utility, but we must do that to fully appreciate the effects of each change (Wertz 14). The MoEs that we used:

- Responsiveness MoEs
  - Total response time- time from when a new request for data is made until the data is given to the user or requestor
  - Development time-total time to develop a needed technology
- Goal oriented MoEs
  - Level of preparedness-level of readiness to react to world events
  - Measure of utility-ability to predict, protect, respond, retaliate, restore, rescue, contain or limit collateral damage
- Flexibility- ability to use the same asset for more than one mission, either at the same time or at a later time
- Risk-probability of a successful deployment
- Coverage-number of spacecraft required to achieve a given level of coverage or given frequency of observations
- Cost-total cost

These indicators affected our decision making process and ultimately helped us decide the changes that were most important. Responsiveness is the perfect measure for our study, because it translates directly into our ultimate goal. The other measures listed help quantify other effects that could bring responsiveness as well. Cost itself is not an important measure, but with respect to providing more money, it can indirectly provide responsiveness. For instance, if

we came up with a technology that allowed us to launch for a fraction of the traditional cost, we could provide more launches for the same total cost.

Using Measures of Effectiveness allow us to quantify each change, and eliminate changes that do not result in responsiveness to the customer. There are many changes that would arguable make space more efficient, less expensive or less risky, but if they did not ultimately improve responsiveness they were no longer considered. MoEs provided a significant focusing function for our group to come to our conclusions.

III. DEPARTMENT OF SPACE

Early on we knew space needed a unified structure to be more responsive. The decision we had to make was whether to unify the NSSE under a cabinet level organization or a service level organization within the DoD. We decided space transcended the military structure with interests rising in business, travel and exploration. We need to stand up a new cabinet level organization, the Department of Space. Providing a unified command structure will allow us to shape the entire organization to be more responsive.

The idea of centralizing command, control and authority of space assets is not a new one. It has the support of many independent organizations like the 2001 Space Commission and the Government Accounting Office (GAO) and is the topic of countless PME theses at all the various Service schools. In the 2003 report titled *Military Space Operations: Common Problems and Their Effects on Satellite and Related Acquisition*, the GAO wrote of the troubled space acquisition process:

> "…there is a diverse array of organizations with competing interests involved in overall satellite development—from the individual military services, to testing organizations, contractors, civilian agencies, and in some cases international partners. This created challenges in making tough tradeoff decisions, particularly since, for many years; there was no high-level official within the Office of the Secretary of Defense dedicated to developing and enforcing an overall investment strategy for space."

Creating the Department of Space assigns the responsibility for "developing and enforcing" an overall strategy as well as the responsibility for executing it. We feel that a high-level official within OSD is insufficient in that it still does not account for that diverse array of organizations outside the DoD.

The creation of the Department of Space is at the heart of our solution to make government space more responsive to the customer. This new Cabinet-level department would

be made up from the various space components of the military, intelligence community, NASA, Department of Commerce, and government-funded scientific endeavors. This includes, but is not limited to, all Air Force, Navy, Army and Marine space elements (commands and headquarters), all of the NRO, the space components of NSA, NGA, DIA and the CIA, the space portions of NOAA, and NASA. It will also encompass regulation of future commercial space ventures. This takes the idea considered under Rumsfeld's Space Commission report (to put the AF and NRO space assets under one authority – the USecAF) and does it one better. The chart below depicts the roll-up into the Department of Space. (The dotted line from "Commercial" indicates that the Department of Space only has regulatory authority over commercial space, we are not nationalizing the industry altogether.)

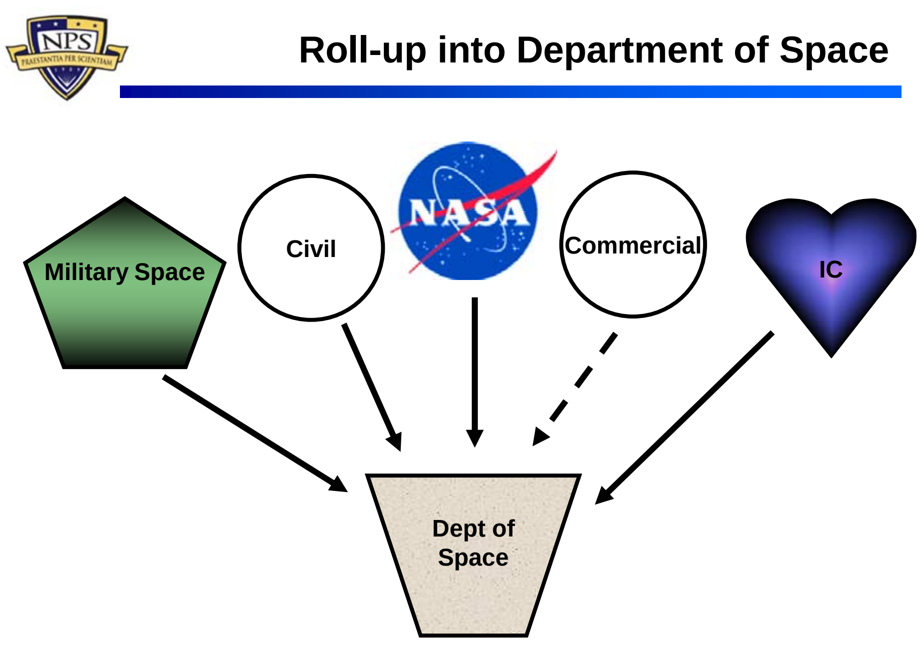

Figure 2 Roll-up into Department of Space

When deciding who to include in the Department of Space, it was almost easier to start with whole organizations and then decide which parts to cut out. Specifically considered and

excluded from the Department of Space are ICBMs (should remain part of the Air Force), the aeronautics portion of NASA (we will give that to the Air Force), and the Missile Defense Agency. While the Department of Space will launch and operate the satellites that are used for Missile Defense, the overall mission will remain with MDA. Similarly, the Department of Space will provide services to the Intelligence Community (like signals and imagery) but the appropriate Intelligence agency will be responsible for the analysis and dissemination of these products.

As a service provider to the DoD and IC, the Department of Space will have a senior level board to consider, approve and prioritize the requirements of the customers. The Department of Space will program funding based on the customer priorities. The organization and process will be similar to the DoD's Joint Capabilities Integration Development System (JCIDS) and Joint Requirements Oversight Council (JROC). The JCIDS and JROC are in place to approve and prioritize requirements from the competing military services just as our process will prioritize between military, intelligence, and scientific customers.

The Department of Space will control the funding and budget authority commensurate with the levels held under the previous DoD, IC, or other government agency. This combined requirements and funding process under a single authority will allow the Secretary of the Department of Space (SECSPACE) to make prioritization decisions across the entire space portfolio. Currently, the various DoD Service Secretaries must make funding trade-offs between the many competing platforms in their service. Satellites compete against planes in the Air Force and ships in the Navy. At the DoD level, they then compete further against funding for tanks and helicopters and ground forces. In a time like today, the ground wars in Afghanistan and Iraq are the immediate pressing need, and funding for satellite constellation replenishment and

development take a back seat. We are sacrificing our future to pay for our current programs and this short-sighted approach will no doubt come back to haunt us years down the road. Under a Department of Space construct, on the other hand, the SECSPACE controls a dedicated space budget and can make tradeoffs within space to fund space. System replenishment, future development, testing, scientific exploration, manned space flight will only compete against each other rather than all the other combined priorities of the DoD, IC, DoC and NASA. Some years, constellation replenishment will be more critical than future development; other years we will want to increase funding to a manned space program that is ready to make giant leaps for mankind. The important thing is that under Department of Space, a single authority will have the capability as well as the vision and insight to know how to prioritize those programs.

The other advantage of Department of Space is the centralized command and control over all space programs. This is especially helpful when it comes to policy. Implementing and enforcing policy decisions is impossible in the current organization of space. Other than the President, no one person has control over all the U.S. space assets. The President sets the national space priorities and policies, but Presidential directives do not get down to detailed levels. That is normally left up to the Department-level. In the case of space, there are too many disparate Departments, Agencies, and other organizations to coordinate and enforce any cross-organizational policies. We can rarely even get the Services in the DoD to agree to policies and priorities let alone also include the IC, NASA and others.

In the current environment, the DoD or NRO build and launch satellites to support their customers. They try to accommodate the customers' requirements and prioritize within their limited resources. Often times, there are conflicting requirements within the DoD or IC among the many customers. The Navy wants communication with wide coverage areas to bring

bandwidth to their ships, while the Army and Marines want concentrated beams to bring them more throughput for UAS feeds. Some customers want as much throughput as the satellite can produce, while others (Special Forces) are willing to sacrifice bandwidth for protections like anti-jam, LPD/LPI (Low Probability of Detection/Low Probability of Intercept) and frequency hopping. Meanwhile, in the IC, the various customer agencies fight for intelligence collections over their respective high-priority areas. Decisions may need to go all the way to the SECDEF or DNI level to get resolved. Management is best done at the lowest levels; a program can grind to a halt if waiting for a Secretary-level decision.

There is even less prioritization of requirements and resources external to DoD and DNI. Currently, there is no easy way to reduce funding from an Air Force program to plus-up an NRO program (or vice versa). It would take Congressional action to take budget authority from one department and give it to another, and there would be untold bloodshed defending the dollars. Instead, a program in one organization may be delayed or cancelled while a "lesser" program in the other organization continues. Within the Department of Space, there is oversight and access across all space programs and the ability to increase funding in any one at the cost of another.

The Department of Space organization (Fig. 3) is modeled after the DoD and then changes were made as appropriate. We broke the Department up into three areas: the Secretariat, the Department of National Space Operations, and the Department of Space Exploration.

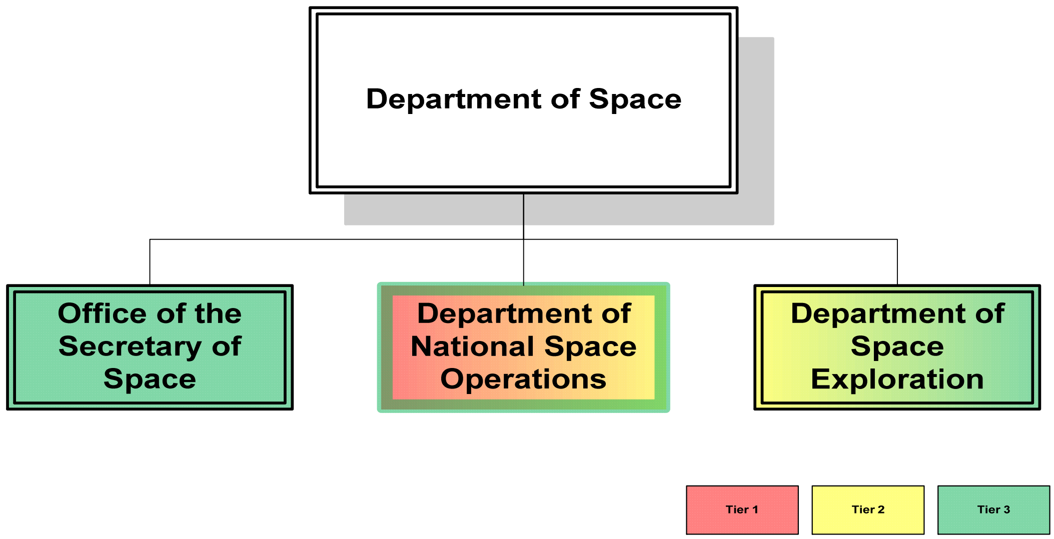

Figure 3 Top Level Leadership of the Department of Space

The Office of the Secretary of Space is composed of the Secretary of Space, the various Under Secretaries and Assistant Secretaries and their staffs (Fig. 4). They are the headquarters leadership, responsible for the long-term planning, policies, organization and running of the Department.

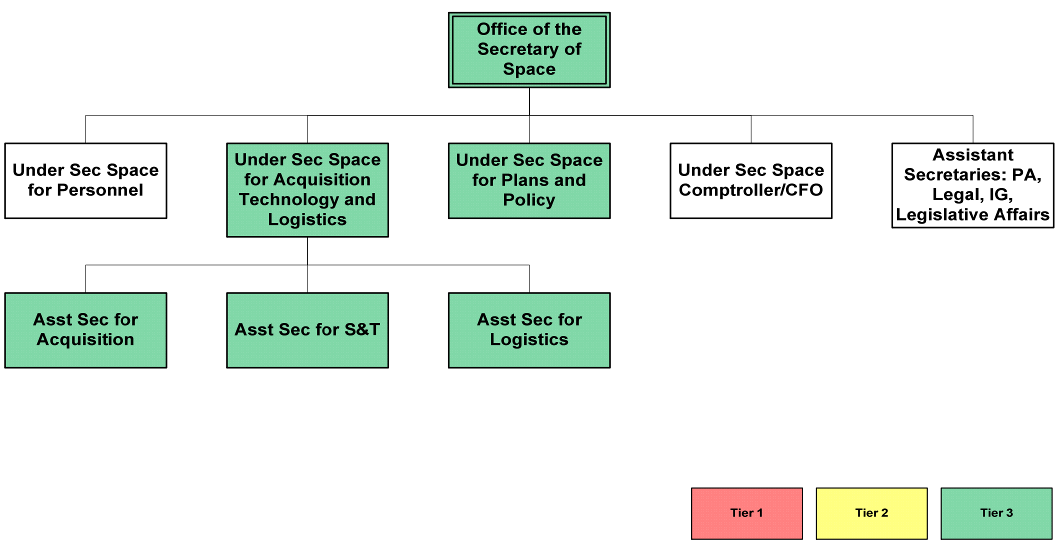

Figure 4 Secretariat of the Department of Space

The Department of National Space Operations (Fig. 5) is the part of the Department of Space that provides support to the military and intelligence communities. The functionality previously found in places like Air Force Space Command and the NRO is now found here. This organization is involved in responsiveness at all three Tier levels. For example, the Space Operations division includes the day-to-day satellite operations and constellation management, as well as the consolidated operations centers for overall space situational awareness; all Tier 1 functions. The Launch Operations division includes the management of launch vehicles, facilities and personnel at all the federal launch sites; all Tier 2 functions. The Strategic Plans and Policy Division ties in with the Secretariat and ensures close coordination of long term (Tier 3) planning. We will go into more detail about the divisions we have designated to a Tier function. The divisions without color are important, but we did not develop these ideas enough to designate to a Tier function. We considered them outside the scope of this project.

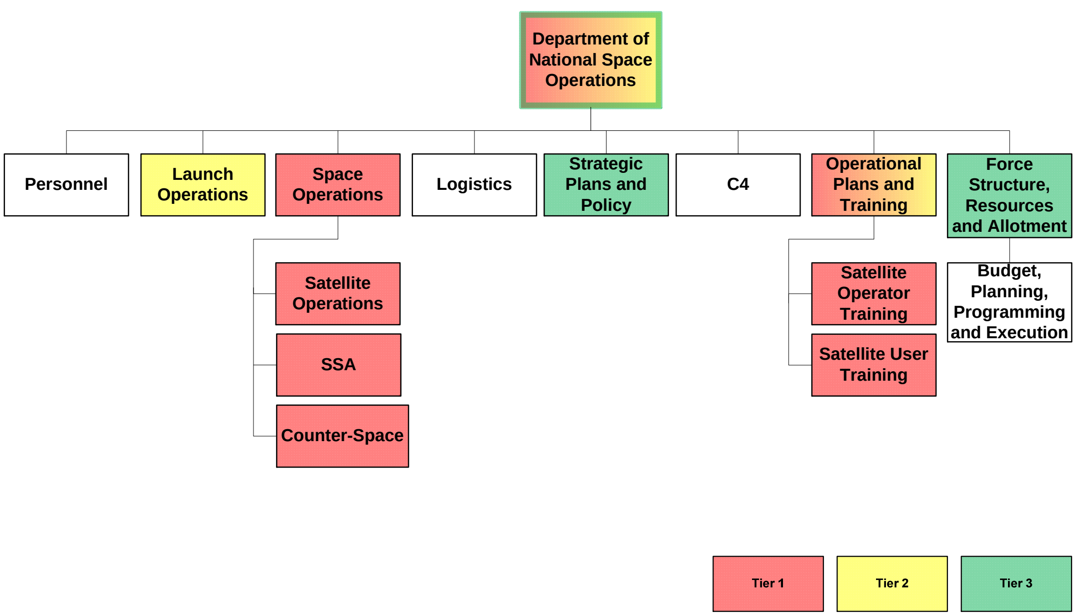

Figure 5 Department of National Space Operations

The Department of Space Exploration (Fig. 6) regulates commercial space, supports civil space use, and is the provider of government-funded scientific space missions. This is where the NASA space functionality now resides, among other things. This organization has mostly Tier 3 functionality because of the less urgent nature of scientific space. Note the dotted line to the Launch Operations Division, which is in the Dept of National Space Ops, because the Dept of Space Exploration does not have its own Launch capabilities. They rely on the Launch Ops from the Department of National Space Operations to support their scientific missions. We gain efficiencies and experience by having one organization manage launch for the entire Department.

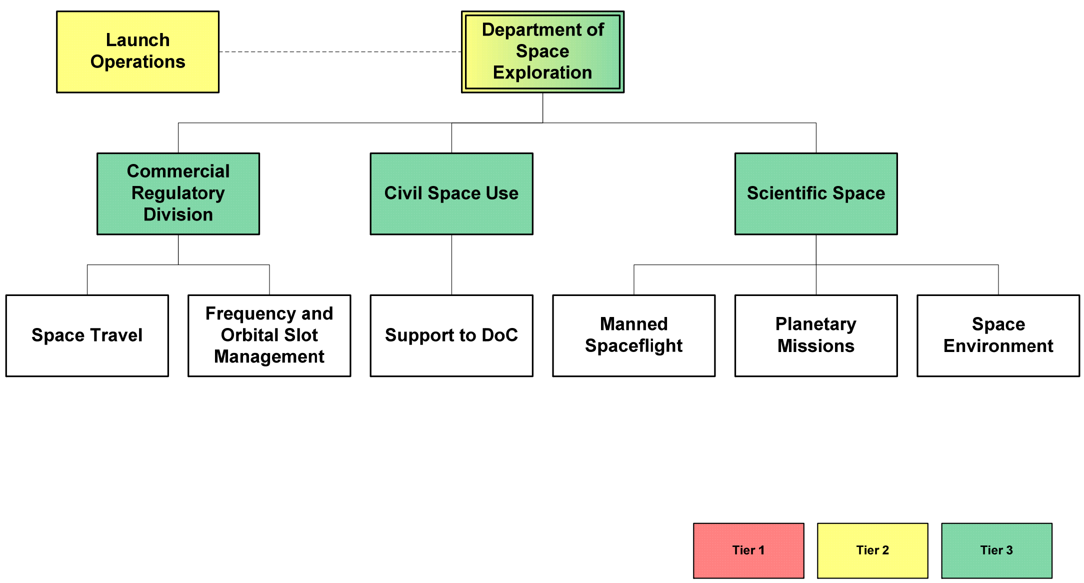

Figure 6 Department of Space Exploration

For the most part, personnel for the new Department of Space will come from existing space personnel in the organizations we will be drawing from. Supporting organizations and staffs like finance, personnel, legal and the like will come from the "donating" organizations as well. For example, if we cut 10% of the Air Force for the space experts, we will also take 10%

of the people from the support organizations. The biggest plus up will probably be at the Headquarters level. Even though we will absorb the space-related HQ-personnel from the Services, Joint Staff, and IC, there is a lot of duplication needed at the higher levels.

In terms of real estate, the DoD currently spills out of the Pentagon into places like Crystal City and Rosslyn. If we remove the space-related functions from the Pentagon, we can put non-space back into it like the Air Force International Affairs organization in Rosslyn and take over THEIR offices outside the Pentagon. Other space-related organizations and ops centers currently on military bases (like the Air Force Space Command Building 1 on Peterson AFB and the various Space Operations Squadrons at Buckley and Schriever AFBs) will stay where they are as tenant organizations. We will make financial and support agreements with the DoD to provide maintenance, power, facilities, etc.

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IV. ESTABLISHING AND DEVELOPING A CULTURE AND PHILOSOPHY

In order to make improvements in any organization or individual, the end state must be well defined. Improvements do not happen in a haphazard manner or on their own. Specific steps must be taken to chart the course toward the desired goal for measurable improvement. There are three steps toward improvement: 1. List what is necessary and important and needs to improve. 2. Develop a philosophy. 3. Set a direction with specific goals (Fuchs 1-7). The Department of Space should follow these guidelines to establish and maintain an organizational culture of responsiveness.

To improve responsiveness in the National Security Space Enterprise, it is important to have all personnel adopt a culture that promotes responsiveness. The organization as a whole starts to be responsive when there is a common underlying identity of all personnel and each decides to be responsive in his personal outlook and actions. "Organizational culture is a system of knowledge, of standards for perceiving, believing, evaluating and acting . . . that serve to relate human communities to their environmental settings" (Allaire 198). The Department of Space must assimilate all the varied and disparate sub-cultures that exist currently within the NSSE in order for all personnel to embrace and share this improved overarching idea of responsive support to the United States.

The leaders' cultural messages should address ambiguities that are beyond the scope of any organizational subculture to explain to employees. Top management must consistently make highly visible business and personnel decisions that reinforce the organizational ideologies, values and norms for success. Cultural change then relies on leaders' communication techniques

that cross subcultural boundaries and carry messages about ideologies, values and norms that can be internalized by all employees (Organizational Culture).

First, the overall mission of the Department must be known and understood by all personnel working in or with the Space community. The mission must be the motivator that each person contributes their efforts to the benefit and defense of the entire nation. This foundation in patriotic service will support the population at large as well as those serving in the armed forces, intelligence community, business and science.

A. MISSION

The Department of Space shall provide space-based capabilities for national defense, information, communication, trade and exploration.

B. STRATEGIC VISION

Key leaders across all levels of the Department of Space are responsible for the Strategic Vision of the entire organization. These principles should be discussed and understood across the departments, divisions and components that make up the Department. All personnel need to recognize what the vision of the whole organization is and how it relates to the overall mission, their department or office and in the daily conduct of their duties. This common identity with common vision establishes the culture required across the organization. The following is our group's vision for the Department of Space:

Responsiveness — Lead, manage and coordinate the national response to space-based needs for national defense, information, communication, trade and exploration during routine & crisis actions

Organizational Excellence — Create a culture that promotes responsiveness with a common identity, innovation, accountability and teamwork to achieve efficiencies and effectiveness

Awareness — Identify and understand threats, assess vulnerabilities, determine potential impacts and disseminate timely information to the intelligence community, military and space communities and the American public

Prevention — Detect, deter and mitigate threats to the United States space infrastructure

Protection — Safeguard our critical national space infrastructure from acts of war, terrorism, natural effects, or other emergencies

Service — Serve the public effectively by facilitating communications, lawful trade, travel and scientific exploration

C. EDUCATION PROCESS

The education process for instilling the Strategic Vision, based on the Mission is essential to the establishment of a responsive organizational culture. This is done initially through the recruiting process and entry level training, retention of trained and indoctrinated personnel, promotion of qualified members within the organization and regular sustainment.

Recruit and Retain

When brining new personnel into the Department of Space, the human resource personnel must screen based on qualifications and receptiveness to the culture. Applicants who cannot apply the foundations of the Vision or who demonstrate resistance to the necessary level of service and support to the many customers of the Department are unsuitable to the organization's overall responsiveness. Personnel who adopted and demonstrate responsive

actions, thoughts and plans should be retained and rewarded for the positive attitude. Retention bonuses and rewards will be a function of the management at every level and the manpower management within the Secretariat.

Entry Level Training

Personnel joining any organization within the Department of Space require training in their specific tasks and in the overall philosophy, vision and culture. This entry level training will be necessary and the responsibility of the hiring human resources office. The cultural indoctrination should encompass the many facets of the Department of Space and introduce the new member of their organization's storied history, rites, ceremonies, language and symbols (Organizational Culture).

Sustainment

When meeting other members or leaders of the organization, it is important for the newly joined to have the culture modeled by key leaders as well peers. This sustainment is important to the perpetuation of the vision by making it a part of the organization's daily life. Additionally, the observance of ceremonies like the anniversary of the first launch of Sputnik, an artificial satellite, in October, human space travel with "Yuri's Day" in April and the Apollo 11 mission landing on the moon in July would be appropriate for the Department of Space. Of course, a ceremony and celebration of the creation of the Department of Space would be mandatory!

Advancement

The culture of responsiveness will also be sustained and reinforced when the talented and deserving personnel who demonstrate this attitude and live the culture are advanced within the

organization. By keeping talent and corporate knowledge of the culture in house, the culture will continue to develop from within according to the leadership's Mission and Strategic Vision.

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V. TIER 1

In the context of making space operationally responsive, a Tier 1 response in the time frame of minutes to days is arguably the most important. Further adding to that rational is the repeated comments in reports like the recent GAO report on ORS stating that "senior military commanders have reported shortfalls in tactical space capabilities in each recent major conflict over the past decade" (Space Acquisitions 2). Since the speed of information transfer has rapidly advanced, even in just the last few years, it can be implied that the term tactical is dealing with time-critical situations. The combination of terrestrial systems like advanced data-links and space-based capabilities have shown the warfighter what the potential is, but the mainly strategic satellites can sometimes create bottlenecks in the flow of information.

An uninformed user might envision small satellites that can be launched rapidly and tasked immediately to provide necessary information to the warfighter. In fact, this is a common misconception that has been challenged by many involved in the space community and acquisition. Dr. Ed Tomme, a retired Air Force officer, gave a presentation in May 2007 at the Naval Postgraduate School in which he showed some of the flaws in the myth of TacSat. In his presentation, he assumed that you could achieve a rapid launch capability and build payloads for less than 20 million dollars. The flaw, he opined, was that placing a small satellite into a LEO orbit still resulted in short passes, very few passes per day, and large gaps between passes (Tomme 22). In general, the services needed by battlefield commanders can be supported by terrestrial assets and a space-based response may not be feasible based on cost or physics.

If rapid launch and small payloads are not the single answer to making space operationally responsive, then what is? Examining this question in the context of the new

Department of Space, some immediate possibilities present themselves. Leveraging the unified command, common operating vision, and clear lines of command, there is greater potential for rapid information flow and more efficient management of resources. That leverage, and ensuring the benefits are passed down to the warfighter, is the most effective way of improving responsiveness in a Tier 1 timeframe.

More concrete examples of that responsiveness can be found in the organization and command structure of the Department of National Space. Protection of on-orbit assets, including surveillance of space, provides what is arguably the most important element of responsiveness. Under the Space Operations Directorate the Command Center and Operations Center concept provides major advantages from the tasking of satellites to the dissemination of collected data. The Operational Plans and Training Directorate provides much needed training to both satellite operators and users so that they can operate in the challenging environments of the future.

A. THE SPACE OPERATIONS COMMAND CENTER

The Space Operations Command Center (SpOCC) will be key to making Space Operations more responsive. Our recommended SpOCC architecture leverages the current capabilities and capacity. The SpOCC proposal will utilize existing infrastructure and eliminate undesired redundancies to the greatest extent possible. From our study it is clear that developing the SpOCC will not see large savings in appropriated dollars, but should not require an increased budget commitment. In drafting our recommendation for the SpOCC we asked, “How is the way we are doing things now unresponsive, and how will the SpOCC in 2025 be more responsive?” We also asked, “What needs to be responsive in minutes to days?”

Our current space architecture has many operation and product tasking centers located at various locations. The Joint Space Operations Center (JSpOC), located at Vandenberg Air Force

Base, is responsible for United States Global Space Force tasking. When JSpOC was stood up, it was intended to be the hub for US space control, maintaining space situational awareness and operational awareness of all United States Government constellations. However, the JSpOC was never manned up, or given the authority to be effective. The JSpOC is not a true command center. The information being briefed to JFCC Space is not real-time, or even near-real-time. JSpOC situational and operational awareness resides in a power point presentation that is presented once per day. So, how is JSpOC now? Is it operationally responsive? No. The JSpOC is not near-real-time, and is not operationally responsive.

In addition to the JSpOC, there are a number of other operation centers monitoring various aspects of our on orbit constellations. The NRO Operations Center monitors the NRO constellations, but tasking and processing of NRO products are performed at other command centers, spread throughout the country. The global positioning system (GPS) command center is located in Denver, Colorado, and does not directly provide real time constellation updates to the JSpOC. The US Navy operates its communications satellites from Pt Magu, California. This fractured command structure leads to problems with large-scale, high-level decision making, and is effectively unresponsive.

When commanders in the field lose capacity or capability there is not a single process or authority to restore, or bridge, lost capability. Currently, there is no standard operating procedure or pre-planned response that the deployed units can follow to regain capacity. Additionally, there is not currently a standard approach to acquire additional capacity when cued that a situation is developing.

Our SpOCC needs to be able to achieve the following three Tier 1 capabilities, in order to meet Tier 1 time requirements. Tier 1 is defined as an immediate response and the SpOCC must be able to, in minutes to days:

- Begin Reposition of On-Orbit Assets
- Deploy Appropriate Terrestrial Assets to Augment Lost Capability
- Leverage Commercial Satellites

We also need to take the following into consideration, because these points will impact the way we do business:

- Tier 1 responses may not be able to completely fill the capabilities gap
- Operations must be able to continue without some space assets
- Training and plans should be certified by the Department of Space Operations Directorate

Because we know that our adversaries will do their best to deny us the operating environment we have perfected since DESERT STORM, the warfighter must train in a denied environment. Thus the SpOCC needs to be able to have plans in place that fills gaps taken away by adversaries.

The third specification is to maintain space operational and situational awareness. To make the SpOCC more responsive than our legacy architectures we need:

- Operational Awareness
    - Need a single source of information on all space based assets
    - Track health/welfare of all buses and payloads
- Situational Awareness
    - Need a single source of information on all space based threats
    - Should include space weather, ASAT, and predictive analysis
- Desired effect of combined OA and SA is ability to predict rather than react

To be more responsive than our legacy architecture we propose establishing a SpOCC. The Department of National Space Operations SpOCC will be similar to the existing JSPOC, in

that it will adapt the operations center that is currently located at Vandenberg, California. Figure **7** provides a depiction of the high level view of the SpOCC.

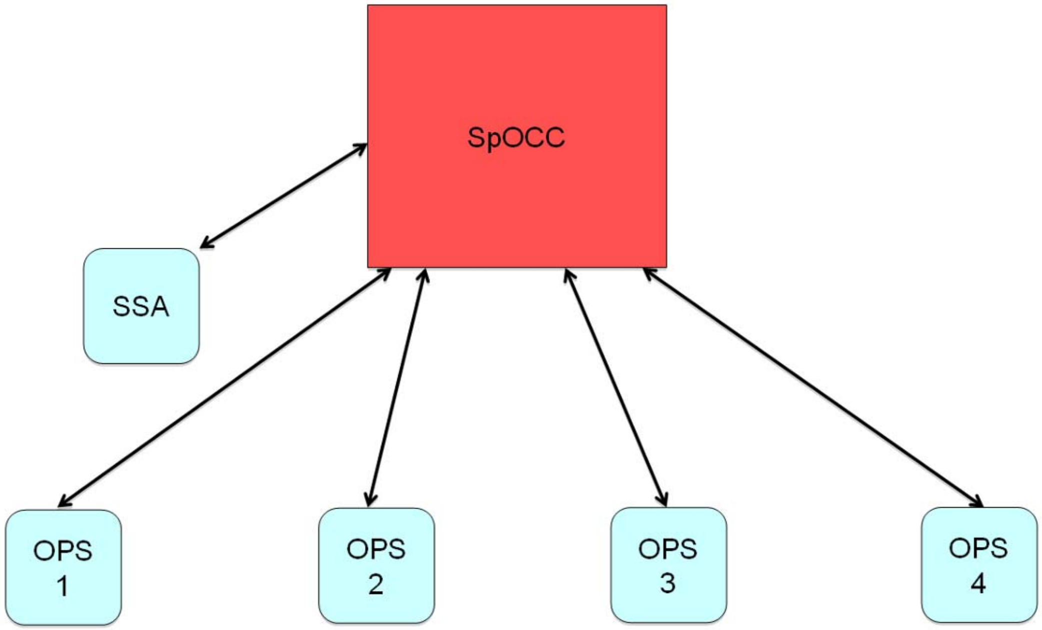


Figure 7 Space Operations Command Center

The SpOCC will provide the focus point for the Department of Space Tier 1 response. The SpOCC provides the highest level of approval authority in order to meet Tier 1 time requirements. Much of SpOCC response capability and capacity is laid on the foundation of awareness, both situational and operational. The SpOCC is the first place customers in the community call to report, request or task Tier 1 assistance.

Reporting directly to the SpOCC is the Space Situational Awareness (SSA) Division. SSA is the near-real-time answer to current and predicted events in orbit that will affect our constellations. Having the SSA function collated in the SpOCC will reduce time in the event action is required, either defensively or offensively.

Also reporting to the SpOCC are all of the subordinate Operations Centers (OPS). From Figure 7, it can be seen that the individual OPS Centers, OPS 1, OPS 2, OPS 3, etc, all report directly to the SpOCC. The goal of the individual OPS is to command by negation their portion of the overall space system. For instance, all of the individual constellations that are currently operated out of Vandenberg Air Force Base will be centralized, such that a single OPS Director will be responsible to the SpOCC for all activities at that site. This consolidation will eliminate redundancy, create efficiency, and provide better overall situational and operational awareness.

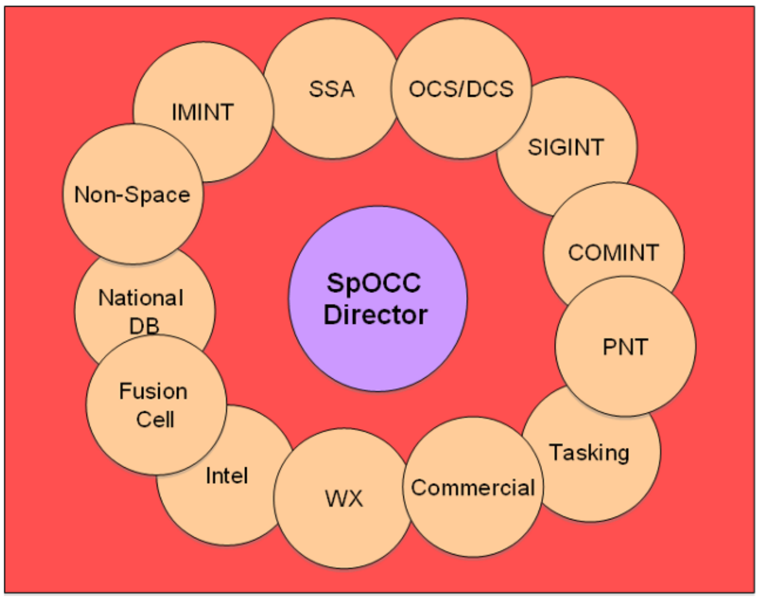


Figure 8 SpOCC Floor

Figure 8 provides the functional layout of the SpOCC. The SpOCC is connected to the global information grid. This transparency provides real time situational and operational awareness to and from the customers. It also provides near real time communications of requirements and requirement solutions to and from the SpOCC and the customers. In the

SpOCC are subject matter experts (SME) for all of the areas that are required to make space products available to customers internally and externally to the SpOCC.

Some of the SMEs represent the IMINT, SIGINT, COMINT product lines. Also represented are SMEs for SSA, OCS/DCS, and intelligence, as it relates to space. Additionally, experts on space weather and precision, timing and navigation are situated on the floor.

The commercial SME has visibility on all on orbit space assets that are being utilized via contract, or can be leveraged to provide capability or capacity to the department of space. He or she would have direct access to a contracting officer so that commercial products or capacity can be obtained if required.

The non-space SME has visibility of non-space assets/solutions that may be located in specific theatres, or could be deployed to provide non-space solutions to requests. In our assumptions it was stated that most theater ISR would come from non-space assets, thus the non-space assets will be significant.

The tasking SME has a big picture view of what resources are available to be tasked. Because the SpOCC has situational and operational transparency the tasking SME, knows what individual OPS Centers are available for tasking. This tasking will become critical when product providers are experiencing technical difficulties, or when significant tasking loads are present.

The national database (NDB) SME has complete visibility on the individual databases that contain Commercial and National SIGINT, ELINT and IMINT databases. This SME will not maintain the databases, but with automation can quickly determine if the databases have a product solution that would allow an immediate response, saving time, money and resources. An example of product solutions for IMINT could be providing a lower resolution commercial product that is in the commercial database, rather than scheduling a national system.

The Fusion Cell SME serves to provide a coordinated response, for situations that do not have an available PPR. The fusion cell will be composed of SpOCC SMEs that will work together to solve an emergent requirement. The fusion cell can be viewed as a tiger team similar to the Tier 3 technical response that is being proposed to solve emergent technical requirements. He or she works directly for the Director and has a high visibility of the situational and operational awareness being maintained by the SpOCC, and the current required tasking. He and his team will work to quickly develop critical tasking requirements that do not need PPRs, so that the Director can make a time sensitive decision.

The SpOCC OPS Director is the senior person on watch and is a Flag or SES equivalent. The Director is the voice of the SpOCC, reporting directly to the Deputy for Space Operations. For the most part his role is of a supervisory nature. All SMEs and OPS Centers have command by negation and shall follow PPRs as required. Where situations are presented that have not been considered or planned for, the Fusion Cell SME will provide recommendations to the Director, who will approve or disapprove as appropriate. The Director will directly communicate with the IC, Government and DoD customers whenever the situation requires.

Reporting directly to the SpOCC are the individual OPS Centers. As mentioned previously, these centers are the result of on site consolidation of the various space ground command and control centers that are spread through out the globe. See Figure 9 for an example OPS Center.

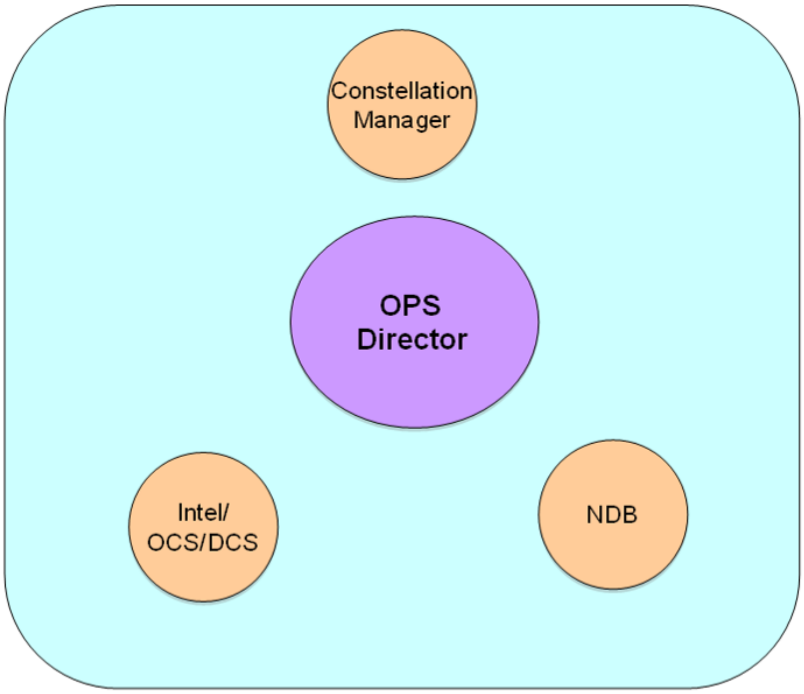


Figure 9 Example Operations Center

The individual OPS Centers will have similar structures, but allow for specification as required. In this example each OPS Center has a Director responsible for all space operations being conducted at the site.

Each OPS Center will have managers responsible for each individual constellation. For instance, Colorado Springs would have managers for the DSP and GPS constellations, each responsible for all aspects of their constellations.

Each Ops Center would also have an Intel, OCS, DCS SME responsible to the Director for the on orbit safety of the constellations. With good intelligence and well thought out pre-planned-responses, on-orbit risks can be eliminated, reduced or mitigated.

Each Ops Center will also have a Data Base Manager, who is responsible for the individual constellations products being added to the specific data bases, minimizing delays and duplication.

This proposed architecture would reduce redundancy, decrease response time and make the Department of Space much more responsive. Much of the capability presented in the SpOCC is present in our legacy architecture, but it is not open. Many of the legacy capabilities that will be incorporated into the SpOCC are stove piped. The SpOCC will knock down the stovepipes, making the overall system more capable and responsive. Measures of Effectiveness for the SpOCC:

- response time from time capability is lost to time capability is restored
- response time from time it is recognized that additional capacity will be required to time additional capacity is available
- the latency of situational and operational awareness
- the transparency of Tier 1 requirements between the customers and the SpOCC
- the transparency of the NDB and the ability to provide products from existing database to customers, when it is not feasible to use space-based systems to obtain requested products.

B. SPACE SITUATIONAL AWARENESS

Protecting our space assets depends on three important operations divisions: Space Situational Awareness, Offensive-Counter Space and Defensive Counter Space. Each of these divisions has data pathways to other government agencies and commercial companies that work in space. The Space Situational Awareness division has particular connections throughout the intelligence agencies. They also have data flow from every ground station around the globe. The Counter Space divisions have close ties with those in the science and technology arm of the Department of Space. These connections with S&T will aid both counter space missions and provide the visibility of DCS/OCS requirements.

Space Situational Awareness is the cornerstone to keeping everything that we have in orbit safe from hostile action and the hostile environment in which they exist. Every SSA division throughout the Department of National Space Operations has a strong interaction with each satellite program. This Operational Awareness gives the Operations Director at the separate locations the health and welfare of their satellite or constellation. The SSA division has data flow with other government and non-government agencies to help those who need to know the health and welfare of particular satellites. SSA division provides its critical information to the Space Operations Command Center, who keeps the customers apprised of the overall operational picture of the national satellites.

Space Situational Awareness in each individual location is not necessarily planned as an entire office manned by a team of experts, but may be done by select individuals as a collateral duty. This job could be done in conjunction with an operational awareness job done at that location. All the data collected at the separate location will feed back to the SpOCC for the larger SSA division to process and review. The SSA at the SpOCC will be manned as a 24/7 job by at least one person per shift. The SSA can help the Director of the SpOCC make larger decisions for all of Department of Space.

Every ground station that the Department of Space can obtain information from will help feed the overall SSA for the SpOCC. Every ground station will be configured to communicate with every satellite. These ground stations are critical to the next step within the Space Operations Directorate, which is Offensive and Defensive Counter Space.

Offensive and Defensive Counter Space

Offensive Counter Space quickly gets classified to very high levels but on the conceptual side of things, there are a multitude of things that we can put in space to give us an offensive

capability. A short list of options includes anti-satellite weapons, maneuvering satellites, projectile and energy weapons. Each of these can be from both space or ground facilities. Maneuvering satellites could be small cubesat-sized craft which attach themselves onto other enemy satellites to push them out of orbit. They could possibly de-orbit them for reentry to earth's atmosphere or super-synch them into a non-recoverable orbit. The projectile or kinetic means of attacking a satellite would be the capability of destroying spacecraft or degrading their ability to perform their missions. An example would be the shooting of a missile that would ram headlong into the enemy object either in orbit or in the upper stages of flight to orbit. Energy weapons could flood an enemy satellite with over-powering radio frequencies or some form of radiation that causes massive system failures (David).

The physics involved in accomplishing these offensive tactics is complicated and currently very difficult to accomplish. The Offensive Counter Space works hand-in-hand with the Defensive Counter Space division, because if one division thinks of an idea then the other needs to know how to defeat it. Cooperation between these fields will develop new and innovative techniques that will benefit and better protect US space assets.

Defensive Counter Space has its traditional role of protecting United States assets from space, but the Department of Space will also incorporate using terrestrial means of protecting space assets. This terrestrial focus helps the Defensive Counter Space division keep focus on an enemy's ability to attack our satellites from the ground with directed energy weapons or anti-satellite weapons. Defensive Counter Space, under the Department of Space, has the ability to employ other governmental agencies and services to help stop attacks against our satellites. The Defensive Counter Space department would report up the chain of command to activate additional options, like the exercise of political means via the Department of State, before any

kinetic retaliation would be taken for attacks against our satellites. This avenue would be first in the line of protecting our satellites from ground-based attacks.

The Intelligence Community assets, in conjunction with the Department of Space Defensive Counter Space division, will monitor the possible threats to our space assets. Both will be vigilant in watching worldwide for possible anti-satellite arms build-up or other indicators for any possible attack. With these indicators the Department of Space could again use diplomatic means through the Department of State or other non-military organizations to put a non-kinetic stop to the build-up or other more peaceful courses of action. If these efforts fail to prevent actual war in space, the Department of Space Defensive Counter Space would be ready to defend our space assets to their fullest.

Space Situational Awareness, Offensive and Defensive Counter Space are intertwined throughout the Satellite Operations Directorate, within the Department of Space and other external agencies within the Federal government. The data flow that each brings into the Space Operations Command Center during day-to-day operations and crisis action is vital for helping the Director of the SpOCC and the leaders of the Department of Space make critical decisions.

Dr. Wertz's examples of goal-oriented measures of effectiveness are what the SSA division is using. For the SSA division, a great measure of utility or effectiveness is the level of responsiveness that the SSA division gives to the different OPS Centers, encompassing every level of the Satellite Operations Department. This is a tangible item, which could be measured via training jackets of the individual operators along with showing the trainers their level of responsiveness during exercises. Besides the trainers, leaders at all levels from the Director of Satellite Operations up through the SECSPACE could also see this quantifiable responsiveness. Harder to quantify, responsiveness could also be measured by the ability that the SSA division

has to predict unfolding events. This gains the Department of Space time to respond, protect, retaliate and restore (Wertz "ORS Mission Utility" 10).

A few measures of effectiveness for the Counter-Space division are the ability to respond, to protect, to retaliate either kinetically or non-kinetically, and limiting collateral damage to our own space assets. If the SpOCC can detect and possibly prevent an attack with SSA, then the OCS/DCS divisions could either respond to protect or retaliate with our satellites or ground stations. All of these tools, working in concert, towards the common goal of limiting collateral damage from enemy action and US response.

Training

Many of the crises discussed in the context of Operationally Responsive Space refer to a "Space Pearl Harbor" where U.S. Defensive Counter-Space capabilities are either caught off guard or overwhelmed. The result is that we are left with a crippled space force where our ability to communicate, navigate, and perform ISR is limited. This is the worst case scenario and one that is frequently used as justification for funding research into quick assembly, rapid launch, and other associated technologies. While the merits of that response are discussed in this paper and countless other publications and reports, there is a separate and equally important aspect to this issue. In the hours following such a hypothetical attack, the warfighters must continue to execute their mission to the best of their ability while the various groups that support them will have to rapidly respond.

To prepare for that response in advance, both the warfighter and those that provided the support must be adequately trained. If preventing an attack or loss of capability is the most responsive option we have, planning to operate in a denied environment and beginning the process of recovering is the next iteration. Training lessens the severity of the losses of space

assets and thus diminishes the impact it has on our ability to prosecute a war. Navy squadrons use the phrase "GPS cripple" to describe individuals who have become so dependent on their satellite based navigation systems that they almost can not function without them. This mindset needs to be replaced with a completely different one. Air, land and sea-based units should prepare to navigate without GPS or with reduced accuracy and coverage. They should utilize alternate communications methods besides satellite, and their weapons and tactics training should incorporate similar means. Space-based technology has greatly increased the lethality of the warfighter, but we do not want to provide a single-point of failure for our enemy, that leaves us with no other options.

Similarly, the various operations and support groups that provide these services need to prepare for catastrophic losses of their space based assets. The ways those satellite vehicles or communications networks could be lost are varied and situational dependent, but regardless, there should be a plan in place in case they are taken offline. The Department of Space is in a unique position in that it can standardize training across the spectrum of satellite and space operations. Standard training plans can be implemented and trained to for scenarios that include losses due to enemy action and the space environment. A single loss or the destruction of large parts of a constellation can be trained to. Finally, large exercises can be conducted that encompass many parts of space control, operations and support so that readiness can be tested and assessed in the most realistic situations possible. All of this training should have the eventual goal of reducing the time to respond to a catastrophic loss.

The Director of Operational Plans and Training, whom is subordinate to the Director of National Space Operations, oversees the training and certification of satellite operators and users in regards to their utilization of space resources. The Operational Plans and Training department

is further sub-divided into two sections. The Satellite Operator Training section handles operational plans for the satellite operators. They help to standardize and codify operations and share lessons-learned throughout the department. One of their specific charters is to develop a spectrum of operational responses that can deal with everything from the loss of a single satellite to the loss of multiple satellites in multiple constellations.

Those response plans are vital for responding to threats that could affect the satellites within the Department of Space organization. They are the satellite operations that are critical to national security. The space operations section runs the Space Situational Awareness network and also conducts satellite operations. The satellites run in those two sections provide almost all of the information products required by the warfighter. They provide many services, like communications and Position, Navigation and Timing which are deemed indispensable in today's day and age. Because of their importance, the satellite operators should train at many levels including individual satellites, constellations and multiple constellations.

Individual satellite operators should be trained for an immediate response to either threats to their satellite or threats to their constellation. Those threats could come in the form of conjunctions with space debris, the onerous space environment, or deliberate attacks. The deliberate attacks themselves could be manifested in several forms including kinetic attacks, deception and denial attacks, or network attacks on ground stations to name a few. To adequately train a single operator you will need to augment their initial training with yearly training and certification. The intent of certification would be to show that individual operators are adequately prepared and have the necessary resources to respond immediately to these threats. Inherent in that immediate response is the information necessary to recognize an attack which was previously discussed in the Space Situational Awareness section.

At the constellation level, the entire team should be prepared to handle similar threats as was discussed at the individual unit level. Also, the constellation training will build upon the training and certification and training done at the individual level. Constellations will need to demonstrate that the majority of their operators meet Tier 1 certification levels for the entire constellation to be deemed Tier 1 compliant. Training and documentation should be examined for the entire constellation to ensure that their operational plans are in place and up-to-date. Coordination with Space intelligence and Counter-Space representatives should be done to ensure that those plans are adequate for the changing technology and threats presented by adversarial nation states and rogue operators. Finally, a coordinated exercise should be accomplished on a yearly basis demonstrating proficiency in maintaining continuity during the loss of varying portions of a satellite constellation. The exercise should examine the reporting of losses to the Space Operations Command Center, notification of affected users, response times, and utilization of other space and terrestrial assets to augment capabilities.

Finally, training can be implemented across multiple constellations to examine the result of a large-scale, coordinated assault on our space network and assets. First, this is something that would be virtually impossible to coordinate without the new organizational structure of the Department of Space. Conducted on a semiannual basis, this training exercise would stress the system and expose flaws and errors in many areas. However, exposing those issues prior to an actual occurrence is of great importance, and the lessons learned could also potentially improve coordinated efforts between multiple constellations on a more regular basis.

It is important to look at the scope required and the necessary methods for training all of these operators. Examining just the 14^{th} Air Force which manages a large portion of the United States' space assets can give perspective on the requirements necessary (see Table 1). First, you

can note the large number of organizations and their supporting staff. It is unlikely that large portions of the functions those organizations provide will be able to be consolidated during the reorganization into the Department of Space. An examination of FY 2009 estimates for Air Force spending on training and education shows they expect to spend $2.9 billion dollars total. (Department of the Air Force 20-31) However, those numbers contain only $420.6 million dollars budgeted for Specialized Skill Training and that money is mainly apportioned to specific training subsets that do not include dedicated space training. The largest dollar amount set aside for space training is $4.0 million for Space Professional Development. Most of these organizations will have a portion of their Operation and Maintenance (O&M) budget for training. Traditionally, that dollar amount is small when compared to overall O&M expenditures, and accordingly, the Operational Plans and Training Directorate will not have a large budget with which to operate.

21st Space Wing – Space Control

SPACE WARNING SQUADRONS

- 6th Space Warning Squadron - Cape Cod AFS, Mass.
- 7th Space Warning Squadron - Beale AFB, Calif.
- 10th Space Warning Squadron - Cavalier AFS, N.D.
- 12th Space Warning Squadron - Thule AB, Greenland
- 13th Space Warning Squadron - Clear AFS, Alaska
- Royal Air Force Fylingdales - United Kingdom

SPACE CONTROL SQUADRONS

- 4th Space Control Squadron - Holloman AFB, N.M.
- Det 1, 21st Operations Group - White Sands, N.M.
- Det 2, 21st Operations Group - Diego Garcia
- Det 3, 21st Operations Group - Hickam AFB, Hawaii
- Det 4, 21st Operations Group - Moron AB, Spain
- 16th Space Control Squadron - Peterson AFB, Colo.
- 20th Space Control Squadron - Eglin AFB, Fla.
- 20th Space Control Squadron, Det. 1 - Dahlgren, Va.
- 76th Space Control Squadron - Peterson AFB, Colo.

30th Space Wing – Launch (Vandenberg)

30th OPERATIONS GROUP

- Operations Support Squadron
- Space Communications Squadron
- 2nd Range Operations Squadron
- Range Management Squadron
- Weather Squadron

30th LAUNCH GROUP

- Launch Support Squadron
- 1st Air and Space Test Squadron
- 4th Space Launch Squadron

45th Space Wing – Launch (Cape Canaveral)

45th OPERATIONS GROUP

- **1st Range Operations Squadron**
- **Antigua Air Station (Det. 1, 45 OG)**
- **Ascension Aux. Air Field (Det. 2, 45 OG)**
- **Operations Support Squadron**
- **Range Management Squadron**
- **Space Communications Squadron**
- **Weather Squadron**

45th LAUNCH GROUP

- **45th Launch Support Squadron**
- **1st Space Launch Squadron**
- **5th Space Launch Squadron**

Table 1a. Air Force Space Command – 14th Air Force

50th Space Wing – Satellite Operations and Communication

50th OPERATIONS GROUP

- 1st Space Operations Squadron
- 2nd Space Operations Squadron
- 3rd Space Operations Squadron
- 4th Space Operations Squadron
- 50th Operations Support Squadron

50th NETWORK OPERATIONS GROUP

- 50th Space Communications Squadron
- 21st Space Operations Squadron
- 22nd Space Operations Squadron
- 23rd Space Operations Squadron

460th Space Wing – ISR and Missile Warning

ADF – Buckley AFB

Table 1b. Air Force Space Command – 14th Air Force (concluded)

If training and certification for individuals and constellations will occur on a yearly basis, there will need to be innovative methods employed to ensure quality training while operating with a potentially constrained budget. The Satellite Operator Training division of the Operational Plans and Training Directorate will provide training through on-site assist visits and through delivery of training via electronic means. On-site assists, while more costly in terms of man hours and training dollars, are still important to establish important training criteria and critically evaluate the personnel operating our satellites. Delivering training via electronic means provides flexibility and can sometimes be more cost-effective way to train large numbers of disparate organizations.

Certification teams that travel to each organization to conduct training and certify these units will have some very specific requirements and goals. First, the training teams should be made up of individuals with a minimum of three years experience in satellite operations and should be headed by an individual who has more experience than that and preferably has operational experience with more than one constellation. To assess a single constellation, a team

of at least three individuals given a week should be able to accommodate a fairly thorough examination of the unit. Pre-work should be completed prior to the on-site training to maximize the time where the evaluators are examining the personnel and getting to assess their abilities while watching them actually perform their job. Training teams ideally would be able to spend a three to four week period in a geographic location so that they could maximize time on site with minimal travel time. Potentially the time on-site could be shortened by utilizing weekends since satellite operations are continuous. If training teams are afforded a ratio of twice the amount of time home compared to how long they are gone, then the total number of teams can be calculated based on how many Operation Centers they need to visit.

The electronic means for delivering training are varied and can be tailored to specific organizations. Most organizations can utilize standardized web-based training for basic operations. Tied to a common database, progress can be tracked and basic readiness can be assessed with little work by the Satellite Operator Training division. While this training has some effectiveness, greater utility can be provided by a virtual collaborative environment. Creating an environment that allows for communication, free-flow of ideas, and a sense of community within the satellite operators is essential to creating truly useful training. This concept could be expanded to tools that emulate the consoles of the operators and the constellations themselves. This virtual collaborative environment would be similar to a simulator because tactics and techniques could be tested in extremis with no potential harm to real systems, but it would incorporate users across the spectrum. Other advantages would be recording of chat logs for data mining and the ability to connect users without additional TAD costs. Combining satellite analysis tools like STK™ and massive multiplayer video games to build scenarios and realistic visuals would provide a cost-effective and very productive medium

for learning. Once consider the bane of education, these video game approaches are now in widespread use and even have texts, like Marc Prensky's Digital Game-Based Learning that present a comprehensive description of the methodology. If they were robust enough, these environments could even be used to facilitate the large-scale, semiannual exercises.

Many of these techniques for training and learning can be applied to the other set of trainees, the users of satellite services and products. The men and women of all the services at almost every level utilize some sort of satellite. In particular, the units at the "tip of the spear" are heavily dependent on satellites for navigation, communication, and employing their weapons. If asked to categorize their dependence on those systems, most operators would say they are highly reliant on them. As information is pushed at a faster pace and more traditional skills are automated to allow the warfighter to instead process that information, the skill sets of past warriors have eroded. Unfortunately, this exposes a glaring weakness that would be completely exposed by a loss of some of the more critical satellites.

The Satellite User Training division of the Operational Plans and Training Directorate is responsible for overseeing the training of the warfighter in regards to operating with and without satellite capabilities. While training is already conducted on how to utilize the systems, training for how to cope without them or how to operate in a denied environment is not as common. For example, Commanders are hesitant to conduct exercises where strict Emissions Control (EMCON) is enforced or GPS for navigation is secured because of safety issues. However, if they were ever required to conduct operations in a crisis or war under those same circumstances, they would find themselves and their troops woefully unprepared. Thus, the key is to practice under those conditions during peace time where the only injuries should hopefully be bruised egos, and the lessons learned can be disseminated throughout the services.

Again, this training will require a two-pronged attack. Similar to the satellite operator training, there should be person-to-person training combined with education. The person-to-person training should come in the form of individuals sent to major training exercises. They should have a foundation in DCS, an understanding of the threats, and the ability to influence planning for these exercises. In essence, they need to be able to ensure that realistic training scenarios are incorporated into already existing exercises so that the soldiers in the field have to learn to live without all of the space-based services they have come to expect for some period of time. A single advisor utilized for major exercises that incorporate multiple units would provide a large benefit to many organizations, with minimal manpower requirements. In addition, they need to learn how to ascertain satellite status through the existing Operational Awareness networks. They should have a plan in place to augment capability with terrestrial assets since there will be an inherent lag of unspecified time before all of the previous capabilities will be restored. For instance, High-Altitude, Long Loiter airships could provide an ad-hoc network for pushing data from command posts to troops in the field beyond line-of-sight. Also, utilizing alternative technology for navigation or weapons employment can be trained to in the field during these exercises. Once again, the goal is for the communications to continue to flow and weapons employment to continue even though a possibly large number of satellite assets are not available.

The education portion is designed to augment the exercise training. Web-based training can be used to inform users of potential threats to satellites and allow them to examine their critical vulnerabilities. This then shows commanders where they should focus their efforts and lets them tailor their own planning based on realistic criteria. Also, training on how to get information on satellite status or who to contact in case of technical issues could be delivered on-

line. Sample plans for augmenting or replacing capability lost by satellites could be stored in an online repository and could be linked to units that have adapted them for their own use. Like the other on-line training, any prerequisite training could be easily tracked and reports on readiness could be generated with little effort. The eventual goal would be certify deploying units at the Component Warfare Commander level as Tier 1 certified meaning they have immediate plans at the ready and can continue to prosecute their mission even in a denied environment.

While these plans are ambitious for a section of the Department of National Space that ostensibly is operating on a "shoe-string" budget, they are fully realizable. Utilizing a blend of electronic training media with training representatives in the field or at the Operations Centers would ensure that goals are met while utilizing resources intelligently and efficiently. The end-product is well-trained satellite operators and users that are prepared for the worst case scenario and still can execute their mission even in the most trying of situations. If defeating an attack is our most responsive option, this is the next-best thing.

VI. TIER 2

The Tier 2 portion of the Department of Space is focused on improving space related actions that take place in the timeframe of weeks to months. This effort focused heavily on launch operations and processes for day-to-day business and casualty situations. With the goal of making these operations more responsive in mind, the group analyzed the current system to identify bottlenecks and deficiencies which delay space programs. Items identified for improvement include: 1) Fractured management and accounting, 2) Satellite availability, 3) Facilities (Processing and Launch Pads), 4) Launch vehicle availability, and 5) Integration and Test timelines. These items represent places where breakdowns occur, in today's way of doing business, that lead to increased costs and a general lack of responsiveness (Wertz, "Responsive Launch Vehicle" 2).

Department of Space will give decision making and budget authority to a single authority to implement the required solutions to these problems. Under Department of Space the following changes will be made to improve responsiveness: 1) Use of a common research bus to improve technology injection and maintain launch proficiency, 2) Reduce facility bottlenecks through improved infrastructure, 3) Better accounting for launch expenses and facility use, 4) Reduced test time at launch sites, 5) Mandatory sparing policy for satellites and launch vehicles, and 6) Stimulating industry. Many options were considered and evaluated on a comparison basis. The planned functions of Department of Space and options considered by the group will be discussed in detail in the following pages.

A. COMMON SATELLITE BUS ARCHITECTURE

Due to the harsh environment of space, all new, unproven technology and its accompanying components must undergo qualification testing to establish its reliability and suitability for operations in this environment. The testing of new technology is a necessary, but often lengthy and expensive process. Sometimes, untested technology is not considered for current or future space programs because of the level of associated risk. More often, testing new technology becomes a large part of the development phase of acquiring a new system and it increases cost and schedule in an already difficult acquisition process. Additionally, small commercial space hardware developers are often unable to overcome this barrier to market entry because of the challenges and costs associated with qualification testing.

Vehicle	Payload (Lbs)	Price ($M)	Specific Price ($/Lb)
Pegasus XL	977	15-25	15,400-25,600
Athena I	1805	40-45	22,200-24,900
Athena II	4520	45-50	10,000-11,100
Delta II 7320	6120	~45	7400
Delta II 7920	11,150	~55	4900
Delta IV M	20,158	~75	3700
Atlas V 402	27,558	~75	2900
Atlas V 552	45,239	~110	2400
Delta IV H	52,855	148-160	2800-3000

Table 2 Vehicle Comparison-Prices of American Launch Vehicles

One of the primary challenges associated with space qualification testing for emerging technology is the enormous expense associated with the launch process. A previous study of pricing models for comparison of launch vehicles is shown in Table 2 (Isakowitz 4). Although this study was conducted four years ago, it presents a picture of an industry that is not very receptive to casual or slow scientific development programs considering an investment in space technology. It is also an indicator of the emergence and growth of the spaceport facility and launch vehicle industry as a lucrative business. The commercial launch industry has certainly picked up on this idea, and commercial launch providers like SpaceX have emerged as real competitors to the government launch regime for small payload missions.

The emergence of commercial competition, however, has not to date resulted in the reduction of overall launch costs. Commercial vendors looking to add their innovations to the next available payload for testing, experimentation and qualification will pay what the current market will bear, which, unfortunately, is quite a lot. Of all the expenses associated with developing new satellite systems, including development of new sensors and technology, the launch process remains the single largest cost requirement that programs must fund. One estimate indicated that high launch costs are responsible for about one-half of the total cost of new satellite systems (London 3).

Adding to this cost dilemma for new technology developers is the lack of a common architecture that provides commercial industry with the specifications for a common design to build their products. Thus, each program must virtually start from scratch in their bus design and development or look for a previous platform design that may have provided capability similar to their needs. This “hand crafted” approach drives up the non-recurring engineering costs of new programs and adds to the dilemma presented by the high cost of launch. An example from one

study compared the cost of processors for space use. The current cost of a space certified processor was quoted to range from between $200,000 and $500,000 to provide the same amount of processing capability as found in most personal computers (Summers 5). Ultimately, these factors often prove daunting enough to keep new technology out of the space business altogether.

B. COMMON RESEARCH BUS

The idea of designing and implementing a standardized bus for responsive space has been around for some time. Initially, the requirement to make this standardization was directed by the OSD and resulted in the assemblage of the ORS Bus Standards Initiative, a joint effort including the Naval Research Lab, Johns Hopkins University, MIT, and Air Force Space and Missile Command (Summers 1). This directive was initiated for the purpose of establishing a common standard for a future space bus design. The primary intent behind this idea was to provide a standardized bus for the purpose of generating a responsive space launch capability.

Analyzing the requirements of Tier 2 responsive space, the team identified items that would: a) encourage the development and qualification of new technology for inclusion in future space programs; b) provide a way to drive down the operations cost of space launch for new technology while adding overall value to the space industry; and c) provide a regular program of launches to support that idea. Of primary importance to this idea is the cost effective injection of new technology into future space efforts by providing a low cost, dependable means to attain space testing and qualification. Secondary benefits to this program would also exist. A regular launch schedule for science and technology payload testing would also yield the benefits of improvement and standardization of launch processes at our various launch sites. An additional benefit to the idea of a standardized bus is the possibility that a responsive launch (even launch-on-demand) could be achieved by using these standardized components.

By establishing and publishing the specifications for the common bus architecture for research and development, industry can use these guidelines for all new technology developed for space testing and qualification. This will lead to economies of scale that drive down production costs compared to the current practice of building a unique bus architecture for each launch. Manufacturing costs will be reduced, as will integration testing costs. The common bus architecture presents the possibility of reducing a large portion of required testing through the development of common interfaces throughout the architecture. With common components and standardized interfaces, commercial space industry technology could focus on building their products with the capability to correctly interface with the common bus from design day one. This approach would preserve the cost benefits of a mass producible standard bus, while optimizing performance. It could also reduce the component certification documentation and reduce some of the obstacles that currently exist for the new technology.

We considered the idea of a common bus architecture for ALL payloads (rather than just R&D use), but rejected it after further thought. There is no "one size fits all" for satellite buses. A bus optimized for the eclipse period, altitude and radiation exposure of Low Earth Orbit, for example, would not be optimal for use in Geosynchronous Earth Orbit. Similarly, a bus built to support the power and size requirements of a robust communications satellite could not be the same as a bus to support the delicate sensor suite of a missile warning satellite. In the end, we decided it was best for each program to develop their own unique buses to support their unique payloads. We deliberately decided to limit the commonality of a generic bus to research and development.

Using Wertz' measures of effectiveness for evaluating responsiveness, a common bus for research and development payloads that is used as a "build-to" criteria for industry developers

gains our Department of Space many advantages (Wertz, "ORS Mission Utility and Measures of Effectiveness" 3). In the area of responsiveness, it will decrease our total response time and development time by providing an industry agreed upon standard for future engineering and payload qualification testing. By establishing a common bus architecture, our ability to support various types of new payloads and technology will make this a multi-mission utility supporting platform. As launches are conducted on a regular, continuous basis, the average overall cost per mission will decrease, which will result in a cost savings for all the participants sharing the launch expense. Finally, a common bus architecture will provide the Department of Space and industry an established standard to use to reconstitute assets in the event a responsive launch is needed to replace lost assets or inject new capabilities into orbit.

C. REGULAR LAUNCH SCHEDULE

Along with the idea of a common research bus, Department of Space Tier 2 functions would plan a regular launch program for the specific purpose of promoting the development and qualification of new technology from the commercial, scientific, and academic communities. By integrating various new technology components from these communities into our standard architecture, the cost share among the Department of Space and industry will greatly reduce the impact on each participant. Wertz, in his study of launch vehicle cost models, determined that "for all the options considered, the cost per launch decreases with increasing number of launches per year" (2). In the traditional process, launch vehicles are effectively built for each individual mission and must be ordered months or years in advance. In Department of Space, with a system of regularly scheduled launches, vehicles would be built for inventory and removed for use when needed for common bus launches. Once used, the vehicle is replaced by another. This would

require a greater investment in production cost for the overall fleet of vehicles, but the cost per vehicle would be reduced.

As a model of how this process would work, consider the following scenario. Several commercial vendors, through the national labs or through open dialog with the Department of Space, coordinate integration of their new technology onboard our regular launch program for the next fiscal year. Each of these vendors has products that they wish to test in a space environment for the purpose receiving space qualifications before manufacturing and marketing their products. One vendor has developed a new photovoltaic for power production; another has developed a new lithium ion battery pack; the third wants to test a new imaging payload. Our national labs also have new technology to test onboard this same space launch. Because all three vendors have built their product to work with our standardized bus, integration and testing proves to be a relatively smooth process. Because these vendors are not the sole participants in the launch, they will spread the fixed costs of the launch over a number of organizations, decreasing the cost to each. The Department of Space program for regularly scheduled launch has increased its number of launches per year, the cost per launch is reduced. Processing and launch facilities personnel will refine their processes and operating procedures because of our regular launch schedule, making our crews and facilities personnel more efficient.

D. LAUNCH FACILITIES

One of the biggest bottlenecks and vulnerabilities in the launch process is the limited launch facilities at US launch bases. In the post 9/11 world, it should be clear that redundancy and a disaster recovery plan are important facets of every organization. This is especially true for government organizations vital to national security. US launch sites have yet to learn this

lesson. The lack of redundant facilities at the launch bases not only inhibit our ability to process and launch quickly, but make us vulnerable to natural disaster, terrorism and acts of war.

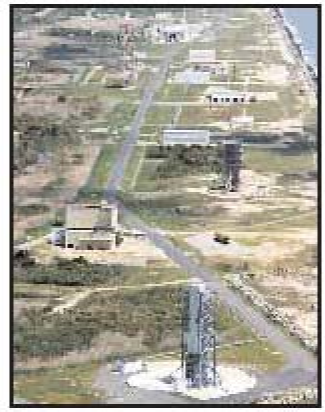
Today's Capabilities

Currently there are many launch bases around the world. For the purposes of responsive space launch, the group focused on bases within the United States and US territories. Relying on launch bases in other countries puts us at unnecessary risk. Our allies today may not be our allies tomorrow, or they may feel pressure from other countries to ultimately and suddenly deny us access to their facilities. By limiting ourselves to U.S. facilities (which we do today anyway), we are able to provide assured access to and better protection of our critical launch infrastructure.

Within the US, the group focused on the four major federal launch sites: Vandenberg AFB, Cape Canaveral AFS (for the purposes of this paper, CCAFS also includes the NASA Kennedy Space Center), Wallops Island VA, and the Reagan Test Site at Kwajalein Island. Additionally, many states, like New Mexico, Wisconsin, Washington, California, Texas and Alabama have planned spaceports. The extent and mission of these spaceports is unclear and varies greatly from state to state. Some are only planning rocket engine test pads, and runways for future space planes. New Mexico stands above most of the other states with their commitment to becoming a major player in the future commercial spaceflight industry. They have committed state funding and are providing financial incentives to companies to base out of their spaceport (Reid A03). None of the spaceports have current plans to host traditional rocket-launched assets and most could not meet the necessary overflight restrictions.

Of the four major active launch sites, Cape Canaveral is the best established and has the largest number of active and inactive pads. They currently have six active pads, 1 more in the works and over 25 inactive pads ("Cape Canaveral"). The 25+ inactive pads are in various states

of disrepair, most with cracked concrete aprons overgrown with weeds. The real estate, however, is still available for future expansion. The six active pads include 2 Delta II pads, 2 Shuttle pads, one Delta IV, and one Atlas V. The pad under development is an old Titan pad that is being converted by SpaceX to accommodate their Falcon 9 vehicle. Vandenberg AFB is just slightly smaller than CCAFS in terms of current launch facilities. They have five active pads and five inactive. The active pads include one each for the Delta II, Delta IV, Atlas V, Falcon 1, and Minotaur (FAA Report 46). Wallops Island VA is a site run by NASA used primarily for their test and small payload launches. They have six active pads for those purposes (FAA Report 47). In the near future, SpaceX will finish building their launch facility for the Falcon 9 (Heavy) launch vehicle on Omelek Island at the Reagan Test Site on Kwajalein atoll (FAA Report 26-27).


Wallops Flight Facility

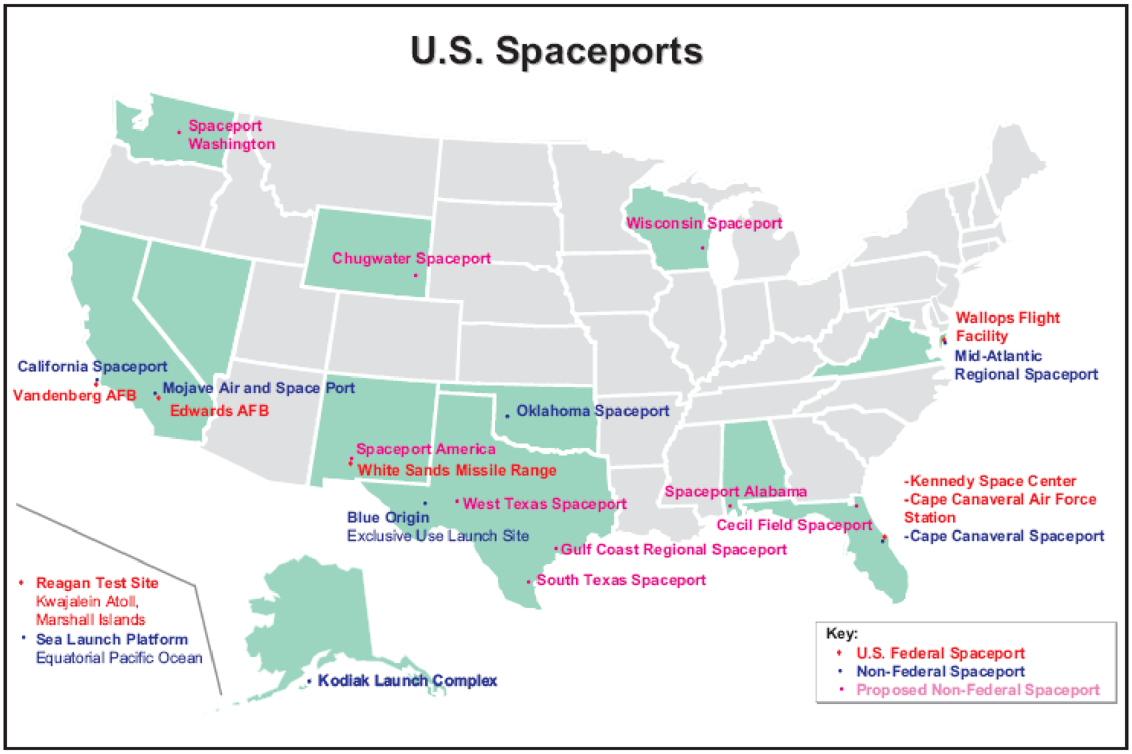


Figure 10 U.S. Spaceports

Issues

This study identified two major causes of the current lack of responsiveness in launch facilities: the absence of redundant facilities and the lack of centralized control. At the two major launch bases that the US government relies on for their most critical national assets, there is only one of each type of launch pad. The pads are proprietary based on launch vehicle type. The lack of redundancy leads to processing bottlenecks; where one mission is waiting for another to finish processing or launch so that they can continue on their path. The advent of EELV has alleviated that somewhat. Heavy missions should be capable of flying on either the Atlas V or Delta IV rockets, but there is still only one of each pad/facility at the site. Besides, the *ability* to launch on either one does not equate to *being prepared* to launch on either one. While

technically feasible, the missions only make a payload adapter for the rocket they are expecting to fly on. If they switch platforms at the last minute, they will have to stand down and wait for another payload adapter to be made or shipped out and change the various fittings to accommodate it.

In addition to bottlenecks at the pads, there are also tie-ups at the processing facilities caused by a lack of centralized oversight. Some of the smaller pads can only accommodate single processing. Even in a two high-bay facility, there are documented cases of satellites being stuck in the transfer aisle and blocking access to either bay. When the Air Force and NRO are sharing processing facilities, sometimes there are conflicts related to program classifications. Access to a processing facility, even though there may be room, can be blocked due to the sensitive nature of the payload being prepared for launch. Before it goes into the payload fairing, access to the payload is highly restricted. There have been cases where unclassified programs sharing the facilities with the NRO have been delayed until the NRO payload is done processing or is fully covered.

Vulnerabilities

While overcrowding is the main cause of the facilities lack of responsiveness, more extreme cases also exist. Natural, accidental, or purposeful destruction of a launch pad or processing facility would shut down the launch pipeline for that vehicle-type until it could be repaired. Weather is highly volatile in the Cape Canaveral area, for example, and hurricanes and tornados are frequent visitors. It is very possible to have a facility wiped out by one. An accidental or deliberately caused explosion on the launch pad or soon after launch could also rain down enough fuel and debris to cause serious damage and months of costly refurbishment, delaying multiple programs. Redundant facilities are clearly needed and they require some

amount of geographical separation. Two adjacent vehicle High-bays, for example, may allow for two missions to process at once, but they could BOTH be wiped out in the same hurricane or explosion. A redundant facility should be located on the same launch site, but far enough away to minimize the chance it could be damaged in the same destructive event.

We also recognized the security vulnerabilities at todays launch sites. Given that we have limited sites and facilities to launch our space assets from, we need to protect them. We can not be responsive if the enemy targets and destroys our Federal launch sites and prevents us from replenishing our on-orbit assets. As we have learned over and over, the most vulnerable part of a space system is the ground station. We recommend ground-based missile defense (like Patriot), anti-aircraft, and similar systems be put into place to protect our launch bases at the Cape and Vandenberg. In case of active conflict, combat air patrols should also operate over the launch bases to provide tight security.

Measures of Effectiveness

We assessed the current situation, found the areas that lacked responsiveness, and came up with ideas to make them responsive by 2025. In making these changes, we graded them against the Measures of Effectiveness described in Dr James Wertz's paper. These MoEs are done in a comparative manner against the systems and processes as they exist today. We made Responsiveness our top priority, but were also able to make measurable changes in the areas of Cost, Flexibility, Risk and Coverage (Wertz, "ORS Mission Utility" 4). There were other changes that we considered and rejected (like common bus for ALL missions, spares for ALL missions, dedicated facilities for each mission, launch vehicles standing by on the pad, launch on schedule rather than launch on demand). For those rejected ideas, the MoEs did not pay off. For example, for the idea of common bus for all missions, the savings in Cost were overwhelmed by

the marked negatives in Flexibility, Risk and Coverage. For the ideas that were accepted, while some MoEs may have been worse when compared to the current situation, there was enough improvement in other areas to make the idea an overall winner.

Multi-Use Facilities

By 2025, we will have redundant, multi-use pads and facilities at Vandenberg and Cape Canaveral. The pads will be classified by vehicle class (small, medium, heavy) rather than specific vehicle type (Delta II, Atlas V, Minotaur, etc). This is not a new idea. The Florida Space Authority converted LC-46 (a former Trident missile test complex) at Cape Canaveral to a multi-use pad and it can handle a range of weights and sizes rather than only one specific vehicle type ("Space Launch Complex 46"). Similarly, the California Spaceport converted SLC-8 at VAFB with an Integrated Processing Facility capable of processing and launching the Delta II, Delta IV and Atlas V as well as small AF and commercial payloads and rockets (FAA report 46-47).

We will begin by constructing Heavy-class back-up facilities at CCAFS and VAFB that could be used with our current Heavy vehicles, but not limited to them. This will provide immediate redundancy for some of our most important national assets. We will construct Medium and Small facilities at each site soon after. Eventually, all launch facilities and pads will be converted to multi-use as they come due for renovations. This eliminates the stove-piping that currently exists and matches up with the changes we propose for crews and processing. While this idea will require some start-up cost, for the design and implementation of the new facilities, it will ultimately result in lower Operations and Maintenance costs. The Cost MoE is worse in comparison with how things are done today (especially in the near term), but

there are significant gains in Responsiveness (Total Response Time) and Flexibility (Multi-mission Utility). In this case, the positives outweigh the negatives.

Due to consolidation of workforce and the efficiencies gained by repetitive launch activities, we plan on limiting our launch sites to the four existing Federal sites. CCAFS and VAFB will continue to launch the missions they do and be the highest traffic sites, Wallops will be the primary site for our R&D satellites using our common bus, and Reagan will serve as the "warm" back-up for the GEO and other Heavy launches. The Reagan Test Site will be our emergency back-up launch point for Heavy rockets due to its proximity to the Equator and easy inject into GEO orbit. We will continue to use CCAFS as our primary site for GEO launches, but if that site is destroyed or there is a national need to launch many GEO satellites at once (due to enemy or natural destruction) we will mobilize the workforce and resources to use the Reagan site as well.

E. CENTRALIZED SITE AUTHORITY

The formation of the Department of Space solves one of the other current problems with space launch: the lack of centralized management of the launch sites. Currently, the diversity of the organizations involved in launch, including the Air Force, NASA and the NRO, creates resource conflicts, prioritization issues, and duplication of efforts. At Cape Canaveral, for example, NASA and the Air Force have duplicate support services (like firefighters) that could be better utilized with concentration of forces. Single ownership and management under the Department of Space will reduce jockeying for priority, and the "launch chicken" that unnecessarily ties up valuable resources. There are currently too many decision-makers in the "go for launch" meetings and the Department of Space puts that decision into a single voice. Centralized authority across all the federal sites also allows for missions to be moved from one

base to another based on facility or workforce availability or shifting national priorities. Centralizing site management costs us nothing, but probably will not specifically save money either, so it is a wash with the Cost MoE. It will, however, lead to better Responsiveness (total response time is reduced through more efficient management) and Flexibility (the ability to direct missions to different facilities, and prioritize missions).

Improved Accounting and Industry Incentives

Centralized command and control will also lead to better cost accounting and reimbursement for commercial launches. In 2000, commercial launches accounted for 40% of the launches at our Federal sites, but only 5% of the funding (The Future Management and Use of… 33). It is in the government's best interest to encourage commercial launch, and we will continue to incentivize them to do so, but we need to narrow the existing gap. The financial incentives should be purposeful, not because of poor accounting practices. Consolidating management at the launch bases will allow us to better understand all the government costs that go into supporting a commercial launch.

The funding obtained from commercial launches will be reinvested in capital improvements at the launch sites. The multi-use launch pads, for example, could be partially funded by commercial reimbursements. Similarly, the United States is currently not a player in the Heavy lift commercial business. Since the formation of the United Launch Alliance (Boeing and Lockheed teaming for EELV Heavy), those companies no longer seek commercial customers (Caceres 17). They have come to rely on the government as their only customer because the government is willing to pay top dollar. The government should encourage ULA to bring in more commercial customers for heavy lift (including international payloads). It will be a win-win for industry and government. It would give them more work and more profit; we

would benefit through reduced vehicle costs from economies of scale as well as more efficiencies in processing. These actions will benefit us greatly in the Cost MoE. We will save money per mission with the ULA idea, and save money per year with better cost accounting and commercial reimbursement.

These proposed changes are a great improvement in the responsiveness of launch. The redundant and flexible launch facilities enable us to do simultaneous processing and near simultaneous launch. In case of large-scale natural disaster in space or war affecting multiple satellites, Department of Space will be able to rapidly deploy spares. It also enables our facilities here on earth to better withstand terror attack, sabotage, or natural weather disaster at one facility and carry on at another. Centralized command and control has always been a key tenant of air power and now we can finally apply it to space as well.

F. CREWS/PROCESSING

Although the U.S. has been in the space business over half a century and most spaceport operations are tightly controlled from within, it is actually quite surprising the extent to which each of these facilities operates independent of the others. Each spaceport and range has its own uniqueness, catering to the vehicle-specific designs and agency or organization specific missions common to that site. Comparisons have often been made between the space industry and the aviation industry for studies in operational design and control. Although each airport facility operates independently, there are inherent similarities that exist between them all: airplanes are moved from support hangars to fueling stations to gates where passengers are loaded. Simultaneously, cargo and luggage are uploaded, pilots conduct equipment checks, and the plane

eventually taxis to a runway for takeoff. These activities are usually conducted in like manner regardless of the airport location.

In contrast, spaceport operations tend to differ in how they conduct operations. Within each individual spaceport there are nuances that in outside commercial industries would be indicators of inefficiency and lack of oversight. Unlike the aviation industry, there is no integrated national approach in the ground and launch operations infrastructure of space facilities. Even funding typically takes place at the implementation phase of vehicle architectures, causing space access capability to be operations-intensive and expensive. Launch pads and processing facilities are usually built to support a single specific vehicle; launch support personnel are usually industry contracted, proprietary personnel that conduct vehicle specific support; and launch site coordinators tend to have little oversight of the status of each program as they approach various milestones in preparation for launch, since much of the processing is scattered between both outside industry locations and spaceport processing locations. All of these are indicators of a broader operational inefficiency, which drives up launch costs and leads to launch or program delays. As one study stated,

> "The biggest roadblock to reducing cost and deployment times is the launch platform. Every proven launch service available today requires at least $15M and 24 months from procurement to launch. From payload delivery at the launch site to lifting off the pad is a minimum of six weeks." (Summers 6)

Responsive launch must work to greatly reduce these estimates to meet the Tier 2 definition of responsiveness.

Problems

To summarize the deficiencies within the U.S. launch facility program, the problems exist on two primary levels. On the macro level, the U.S. government aerospace industry does

not view space access as a business, i.e., it is not driven by market requirements, so efficiency and effectiveness of ground operations and processing have not traditionally been considered key points to strive toward. Secondly, operations have tended to be vehicle-centric rather than space transportation specific. Ranges are configured and then reconfigured based on the next launch required and the type of vehicle to be used. This "patchwork" approach of focusing on one vehicle architecture at a time rather than addressing a "suite" of architectures shows a lack of flexibility within the industry. To add to the problem, ground infrastructure improvements are often overlooked as new spacelift programs are developed. As vehicle architectures grow more diverse, space transportation infrastructure must develop more flexible, responsive ground operations and launch technologies that are more interoperable.

On the micro level, there are three primary inefficiencies that we identified in ground facility infrastructure. First is the lack of interoperability among spaceports and ranges. Individual facilities tend to be unique, complex and designed around a specific vehicle. For responsive space to truly function, range operations should be standardized to the highest degree possible, so that personnel and processes are efficient. Secondly, the workforce employed to support launch operations also tends to be proprietary with the commercial vehicle vender they support. The end result is a workforce that is large, specialized, and often transitions between periods of gainful employment and lulls in activity. Thirdly, data systems are disjointed and provide little oversight for launch facility managers to coordinate range operations with the various programs as they reach launch readiness milestones. At the heart of Tier 2 responsiveness is the ability to perform assembly, test, and launch operations in the most efficient manner. Therefore, all of these deficiencies must be addressed for launch facility operations and processing to improve.

Department of Space Changes

In order for U.S. spaceports to achieve responsive launch capability, a serious study of ground processing, launch operations, and air traffic control/range operations systems must be conducted to identify shortfalls. To improve launch facility operations, we recommend several changes that will need to be instituted within the Department of Space. Unlike the current launch range scenario where operations have many months to plan and prepare for each launch, responsive launch will require crews/processing to be more adaptable and have a broader knowledge base of the inner workings of various types of vehicles and equipment. Instituting a standardized operability policy will also positively impact ground launch infrastructure. Launch pads and ground launch infrastructure will be required to accommodate rapid and possibly frequent payload integration, stacking, test, and checkout, as well as launch vehicle fueling, mission planning, etc. To accomplish this, launch ranges will have to upgrade to accommodate responsive launches (Kolodziejski 2). Ground systems will likely require highly robust and reliable automation systems for responsive launch operations. The conceptual launch facility design will most likely incorporate the automation of various processes to facilitate responsive launch times defined in Tier 2 ORS.

Today's space launch facility and processing operations involve outdated technology and equipment that is expensive and time-consuming to operate and maintain. As a result, 45%-60% of the overall life cycle costs of a space transportation system program are attributed to ground and launch operations (Guidi 1). In order to achieve responsive launch, upgrades will need to be integrated into future launch facilities to inject current technology for processing facilities. Like the recommendation to make launch pads multi-mission capable, processing facilities will be more efficient and capable by redesigning them for multiple missions and vehicles. By

increasing their ability to house and process various missions, potential bottlenecks in the processing flow can be avoided and changes in mission priorities can be more easily accommodated to support responsive launch needs.

Networked Status Reports

For launch range operations to work efficiently, launch facility managers should have complete visibility on the status of each program occupying resources at the launch facility (both infrastructure and personnel). With proper oversight and coordination, key decisions to shift resources to priority tasks can be made with minimal impact on the flow of operations. To smooth this process and ensure safety compliance, all processing assembly and test procedures should be prewritten and validated. Testing should be automated to the greatest extent possible via a standard test port. To minimize cost and time, the entire processing, testing and telemetry database should be web based for immediate and real time access by both Department of Space launch facility senior leaders as well as industry contractors. This will facilitate remote troubleshooting or process monitoring by all area experts from anywhere internet access is available.

Government or Government-contracted Launch Crews

Finally, under the Department of Space, personnel involved in launch processes would no longer consist solely of proprietary personnel with ties to commercial industry. Instead, with safety and efficiency as the primary drivers for success, personnel, to the greatest degree possible would be trained to perform multiple operations on a variety of vehicles. The launch facility support workforce would consist primarily of Department of Space personnel or those contracted directly by the department. By training our personnel to work with a greater variety of our launch vehicle inventory and processing facilities, our workforce would be more efficient,

flexible and able to respond to Tier 2 needs. By standardizing range processes throughout the Department of Space, surge requirements to support a responsive launch scenario at spaceports other than the Cape or Vandenberg would be more supportable, responsive, and safe.

By contracting our launch support personnel to work directly for the Department of Space and training them to conduct processing and launch on a variety of launch vehicles, we will add flexibility to our overall mission capability. A standardized launch process throughout the department would also support this measure of effectiveness, as launch support would be virtually the same regardless of the spaceport involved. In 2025 personnel from any launch facility could be used to support a responsive launch scenario requiring a surge of support at a specific location, e.g., at Kwajalein. Regardless of the location they came from, these personnel would speak the same launch "language" and conduct operations similarly, increasing safety, responsiveness, and flexibility. Our total response time to support a Tier 2 mission would ultimately be smoother and more responsive

FULLY-CAPABLE SPARE SATELLITES

Discussing "responsive space" we have to be prepared to deal with events that will require a preplanned response of launching a new space asset. One obstacle to this being possible in a timely manner is the availability of a capable satellite to replace the lost asset. In the current system, a replacement payload would probably not be available because most programs cannot afford the added costs of including spares for contingencies such as an anti-satellite weapon attack. A replacement satellite could not be launched until a new payload and bus could be built or was in the constellation was ready. This lack of spare can also lead to long gaps in coverage, increased costs, or delays.

The current system

In today's vastly separated system, competing interests, like the Joint Strike Fighter and Littoral Combat Ship, take dollars from satellite programs. While space is a national-level priority, it does not always compete well with other interests of the Service. Schedule delays from these decisions to delay funding ultimately lead to cost increases which force cuts in the satellite programs. It is a vicious cycle. Allocating hundreds of millions of dollars for a spare satellite cannot be justified in a program that is already growing due to delays and overruns. Unfortunately, cost has become the primary driver in space development programs, replacing mission effectiveness. (*U.S. Satellite Program…*) There is no common policy or goal; some programs are able to afford spares but most are not.

Additionally, the management of satellite systems has become reactive instead of proactive. Today, because of the tough competition for funding faced by satellite programs, replacement systems are not planned until on-orbit systems are about to fail. It is not unusual for a satellite to be vulnerable to a single point failure and, while each satellite may have a low probability of failure, the collective probability of failure in a constellation is high (Ayati 7). This has the potential to leave wide coverage gaps because a critical point, where a single on-orbit failure would lead to the loss of a required capability, has been reached. Historically, satellite systems have lasted longer than their design lives, but this should not be relied upon as a safety net for poor planning of future systems. Another effect of this type of thinking is the delay in new technological capabilities reaching users. While satellites should be used for as long as they are beneficial, they must be updated as new needs arise.

Priorities

After careful consideration, the overhead assets were prioritized based on how essential they were to conducting operations in the current environment. The highest priority group, Group 1, includes MILSATCOM and GPS. These systems are essential for operations because of the numerous weapons systems that rely on them and the necessity to communicate with distributed forces at all times. Group 2 includes weather and early warning systems. These are not absolutely essential or are also being conducted by terrestrial assets that could be diverted in case of emergency. Group 3 includes the national intelligence systems. This group is "nice to have" but warfare and other operations can still be carried out without them. Commercial satellites, airborne platforms and land based assets can provide much of the same information collected by Groups 2 and 3 for a small theater of operation, a specific area of interest, or for a limited time while a replacement can be produced.

The Department of Space solution

Under the Department of Space in 2025, we will have a mandatory sparing policy for certain systems because it is preferable to use spare satellites to increase robustness rather than try to predict when satellites will fail (Ayati 7). Based on these group classifications, all Group 1 and 2 constellations would be required to have spares built into their programs. This does not mean that these programs would be required to build a satellite that would be put in a warehouse and never flown. Department of Space would employ a "first in first out" spare approach that means we need to have at least two satellites built before we launch the first one.

On the initial production run, two complete, fully mission capable satellites would be produced. The first satellite would be launched into the constellation and the other would be stored at the factory until the next vehicle in that series was completed. Once the next vehicle is

complete, the “spare” will be launched and the newly completed satellite will be warehoused, thus becoming the *de facto* spare. This cycle will be repeated until the last planned vehicle is completed. The final satellite of the legacy constellation should overlap with the planned production of the initial order of replacement satellites which will then follow the same model. This should help reduce the gap that exists today between legacy and follow-on constellations.

<u>Options</u>

Several remedies to this problem were considered including: new acquisition, a common bus system, reduced capacity spares, ground stored spares, and on orbit spares. A new acquisition would take too long because it would require starting from the beginning and working the entire JCIDS process. Even with a reduced timeline for priority programs, limits on expertise, materials, and assembly time would be prohibitive as most components are not readily available. This type of capability replacement would take four to seven years to finally deploy into space. A common bus system sounds good but would either place severe limitations on capability or cause high costs to meet the needs of all users. As discussed earlier, there is no “one size fits all” solution for common buses. Power, thermal, weight, and other requirements vary wildly from one orbit to another. It would be unwieldy to try and develop a single bus that works well with all payloads in all orbits. Reduced capacity spares would incur increased costs in engineering design and production. There are no benefits to be gained to design and build less capable satellites as a gapfiller; they might as well be new satellites altogether. Additionally, these limited-capability systems would not be designed for long duration use. In this case, equivalent functions could be performed by terrestrial assets as a gap filling measure.

Ground spares or on-orbit spares would only add additional costs to programs while providing little or no added value. With no plan for employment, these spare satellites would

only be expensive insurance policies. On-orbit spares face the additional cost of launch and the difficulties of being in the space environment, which is the biggest enemy of satellites. The adversarial or space environment issue that knocked out the original satellite could just as easily knock out the spare. The other drawback to keeping the spare on orbit is that a material problem in the constellation would be in your spare as well as the rest of the constellation and could not be repaired. Also, the use of on-orbit spares requires the ability to communicate with a damaged satellite to realign the constellation (Ayati 7).

Measures of Effectiveness

Evaluation of these options used a more general, comparative method based on the measures of effectiveness proposed by James Wertz for operationally responsive space. The "first in first out" sparing option provides a solid mixture of responsiveness, risk mitigation, and coverage (Wertz, "ORS Mission Utility" 4). Responsiveness was measured in terms of total response time to a Tier 2 need. Risk mitigation was considered on the basis of the probability of mission success. The coverage comparison was evaluated by the number of fully mission capable spacecraft. This option was not the best for every category considered but it incorporates the best advantages for the overall desired goal. The most responsive option is an on-orbit spare policy because assets would already be deployed. This option was not chosen because it would incur ongoing operating costs and be susceptible to the same risks as the other satellites in the constellation.

Responsiveness

The rotating spare option for our top two priority satellite systems was chosen because it provides a fully-capable spare, available on short notice with minimal impact on the constellation and the user. The Department of Space oversight will allow all space interests to compete for

funding based on their importance as space assets only, not against other service specific programs. Mandated spares on the highest two priority systems will ensure that the most critical capabilities are maintained in the event of a catastrophic failure or loss. Proactive management of critical constellations will prevent gaps by overlapping successor systems and allow for the injection of new technologies more frequently.

LAUNCH VEHICLE AVAILABILITY

A significant obstacle that would prohibit a timely replacement launch from occurring is the availability of a suitable launch vehicle. Currently, launch vehicles are purchased as part of a program and managed by several organizations, or delivery of a satellite is taken on orbit and the manufacturer is responsible for launch. Launch vehicles are purchased, assembled, and processed on an as-needed basis. If a sudden need arose, such as a Tier 2 launch, a vehicle may not be available for some time. This would cause significant delays and could lead to crippling gaps in coverage in high interest areas. Realistic timelines are difficult to obtain in a push to avoid schedule delays and miss launch windows. Launch vehicles typically represent 35 to 40 percent of total costs and can be as high as 50 percent (McCartney 32). Because of this high cost, there is little room available to plan for contingency operations in today's system.

The Department of Space solution

In the Department of Space system, two things would occur that would make launch responsive: 1) Programs would be required to purchase a spare booster in a similar fashion to the satellite spares program 2) Department of Space will utilize its common research bus to maintain a continuous launch schedule. The spare booster policy will reduce average cost by increasing volume and, most importantly, ensure that the correct vehicle is available in a timely fashion. A program will buy two of its required launch vehicles with its original order. One vehicle would

go to the required launch site and be processed for the initial launch. The other would be stored at the factory, ready for shipment. This spare would then be used for the next launch in the constellation or for the short notice launch of the constellation spare or another compatible critical mission asset. The next vehicle purchased by the satellite program would then be built and stored at the factory as a stand-by until the next planned launch. This allows for the possibility of launch from a back-up launch site in the event of a casualty by transporting the spare vehicle already on hand.

Additionally, the common research bus program would select a launch vehicle to be used for all of its launches. The planned schedule is for one launch per month to reduce per unit costs, maintain proficiency, and allow numerous opportunities for access to space. Today's studies estimate that two to four launches per year would be necessary to maintain proficiency (McCartney 32). Department of Space will be prepared to launch one research bus per month. This vehicle and bus would be available to meet the needs of any system that was compatible with it. This would allow for a worst case of one month to the next scheduled launch fitting into the Tier 2 timeline.

Emergency recovery launch

Because Department of Space will absorb NASA, an emergency recovery capability will have to be maintained. Department of Space will require that for manned missions, two launch vehicles must be flight ready. One vehicle will be used for the planned launch and one made ready for a possible rescue mission. This will ensure that the crew could be rescued in the event of an emergency. This capacity would be required for both commercial space flight and government exploration missions. An emergency rescue service, similar to the Coast Guard, may even become necessary and would be possible under this plan for operations.

Options

The group considered several options including: stockpiling various launch vehicles, procuring one emergency spacelift platform and mandating compatibility, having ready stand-by vehicles in a fueled or unfueled status, order-on-demand contracting authority, maintaining the current system, and stockpiling one vehicle type per orbital regime. Stockpiling the numerous launch vehicles available would be cost prohibitive due to the variety employed. This option also has difficulty in reconciling the numerous launch sites with the correct launch vehicle. It would be even more impractical to maintain an inventory of launch vehicles at each launch site for contingency operations that may never occur. The following picture shows only the EELV family. (Evolved Expendable Launch Vehicle)

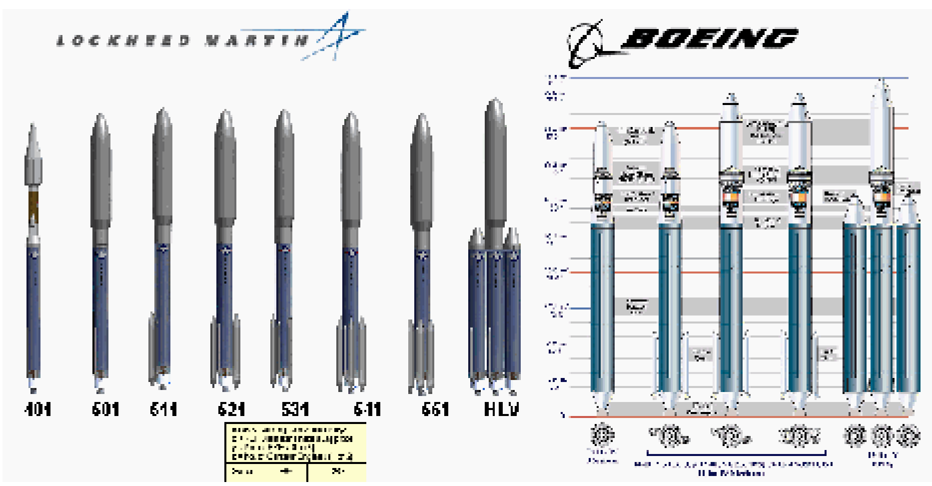


Figure 11 EELV Family of Rockets

Designing one emergency spacelift vehicle to be used for all short order launch cases would place additional burden on program offices and the per vehicle cost would be high because the vehicle would be required to service all orbits and the entire size and shape range of

satellites in production. Launch vehicles have become specialized due to the specific demands of injection into different orbital regimes.

Having vehicles standing by, whether fueled or unfueled, would require significant ongoing costs in manpower, facilities, and equipment. A launch vehicle waiting on the pad would be susceptible to damage and would eventually need to be replaced with out ever being of any benefit to the program. This option would not provide a significant advantage in time or cost.

The use of specific procurement authority was discussed. This option may require the complete production of a vehicle from the ground up, leading to significant delays and falling outside even the several month timeframe. Utilizing a new acquisition process for each new satellite is cost prohibitive and is not responsive.

An argument could also be made for maintaining the current system, accidents excepted; satellites that are built will eventually be launched. Today, the program offices decide which kind and how many of each launch vehicle they need for their satellite systems. This can lead to significant schedule delays, or even coverage gaps, caused by a single point failure. Unfortunately, required launch vehicles represent a large portion of program budgets and are a difficult decision point in any case. In the current environment, it is not practical for a satellite constellation to budget for desired system capacities let alone extra launch vehicles. Cost is the driving factor in most programs today (*U.S. Satellite Program*…). Consideration was also given to procuring spare vehicles capable of reaching each orbital regime. Because of the varying sizes of payloads and their varied orbital requirements, this would also become a large and prohibitive undertaking.

Measures of Effectiveness

Using the Wertz measures of effectiveness as a basis, the options were evaluated on a comparison basis. The adoption of the launch vehicle spare policy was based primarily on its responsiveness and the probability of mission success (Wertz, "ORS Mission Utility" 4). This option was not the best in every category but provided the best overall solution to the problems faced in making space responsive. For example the most responsive option would be to have stand-by vehicles for emergency launch. This option would have an extremely high cost from maintaining the vehicle ready while only improving the response by a few weeks. This cost could not be justified.

Responsiveness

This system of spares, continuous launch cycles, and emergency launch capability will allow Department of Space to respond to any scenario requiring launch in weeks to months. The spare program ensures that each program will have a launch vehicle available for a contingency launch operation. The continuous launch cycle will maintain proficiency and improve performance in integration and launch operations, which can reduce time and cost for launch operations. Maintaining a regular schedule of launches provides a continuous cycle of launches that can be utilized as a backup to the traditional system. Providing a backup manned launch vehicle will ensure that rescue operations can be initiated within one week. In addition to changes made in the operating and procurement cycles, other changes made by Department of Space will support responsiveness as culture. The common operating picture for launch processing, common range management, and networked ground facilities will aid in information flow and help eliminate delays, leading to cheaper, more efficient, and faster launch operations.

These changes will give the Department of Space the ability to respond to emergent needs and improve day to day operations.

Tier 2 Conclusion

These changes to the current system will reduce cost and risk while improving the flexibility and responsiveness of space operations (Wertz, "ORS Mission Utility" 4). Enhanced facilities, better processing oversight and procedures, and shorter testing timelines will improve day-to-day operations. The sparing policy for boosters and satellites and the construction of flexible launch facilities will provide the ability to rapidly respond to a casualty or hostile action with a fully capable replacement in a short period of time. These changes represent the most responsive option for all types of operations that occur in Tier 2.

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VII. TIER 3

We determined that today's space plans and policies lack an emphasis on being operationally responsive. We agreed that a scrub of current space plans and policies, in doctrine, acquisition processes and the science community needed to take place. We reviewed those plans and policies that benefit the function of being operationally responsive and created new policies to increase responsiveness to our customers, the DoD and IC. We envisioned the Department of Space being able to determine future operational and timeliness requirements as the responsive space solutions' leading advocate.

Tier 3 efforts would be placed under the office of the Secretary of Space and Undersecretary of Space Plans and Policies. There, new space plans and policies would focus on timeliness and responsiveness, and would facilitate a new cultural mindset within strategic documents and doctrine. The Department of Space Plans and Policy office would work closely with space S&T/R&D labs and scientific organizations to develop and implement technology standards for responsive space systems. Consolidation of the space community under one department could ensure the organization's responsive mentality is clearly communicated throughout all levels of space acquisition and space science communities. It would also allow limited cross-talk between engineers and scientists working on related classified and unclassified projects, fostering ideas and solutions without necessarily providing program specific information. SCIFs and classified facilities and information systems will enable better communication of requirements and ideas within the department and from users in various geographic regions throughout the world.

The Undersecretary of Space for Acquisition, Technology and Logistics shall create plans and policies focused on responsiveness and ensure they are written into new acquisition development processes. Acquisition models will be altered and processes revamped to provide quicker space system development time. In our opinion, responsive acquisition is not just about developing a new system from scratch to launch and placing it in operation in a shorter timeline, it is also about delivering what was promised on schedule and on budget. Contractors will be held accountable for delays and penalized monetarily. With less budget pressure because of a single authority within the Department of Space allows for more realistic cost estimates without the fear of losing space dollars to a separate program like new fighter planes. The entire space community would be made aware of current programs' progress and status through a virtual, collaborative environment displaying each program's specifics. All programs shall be held accountable to the same rigorous and demanding acquisition requirements, equally and without prejudice. Additionally, the Department of Space Acquisition office will have the authority to reposition efforts between Priority I (national crisis), II (military responsive programs), and III (scientific research) programs. In a national emergency, the Department of Space will have the authority and capability to move scientists, funding and resources between programs depending on were efforts need to be focused (see Department of Space Acquisition Chart below).

Under the Department of Space, Acquisition programs would become better prioritized. Priority of effort could be determined by impact on national security, cost, or schedule requirements. In the chart below, the top two arrows represent acquisition programs that take months to years to develop. They include non-military programs (think NASA) and military and intelligence community programs respectively. The bottom red arrow represents a program that needs to be developed in a shorter time span based upon national security needs. In time of

national crisis, perhaps a threat from a new counter space system, personnel and resources, including funding, would be pulled from lower priority programs to help create or operate a Priority 1 program. Of course, development of programs under Priority 1 would require exceptional funding and entail extensive efforts, but obtaining the personnel power and resources for such an endeavor, under the Department of Space, would be a reality. This is another way in which Tier 3 programs could prove more responsive than todays construct in developing new space technologies and space programs.

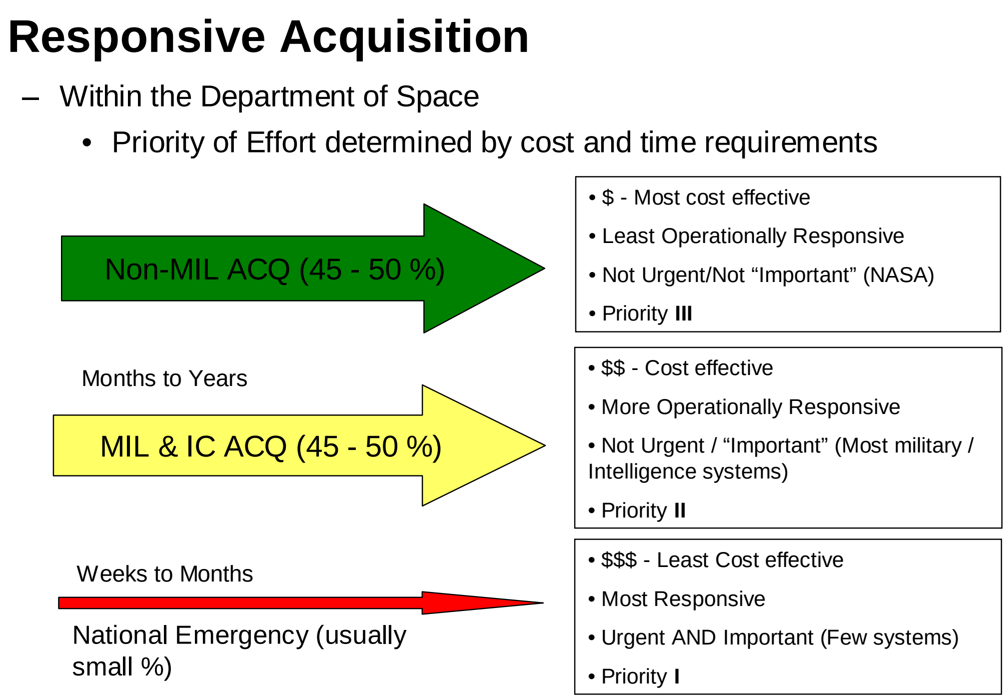

Figure 12 Department of Space Acquisition

An Assistant Secretary for Science and Technology could have oversight and influence in promoting responsive Tier 3 requirements within the space S&T/R&D community. The office will actively seek out responsive space technologies and facilitate programs for faster space technology development, as well as enable quicker technology insertion into operational

environments. Annual space symposiums would continue to focus on up and coming operationally responsive space initiatives. S&T offices within the Department of Space will work closely together to develop long term responsive planning and responsive space technology development. They will cooperate with users from the DoD and IC communities to understand, refine and develop requirements. They will prioritize responsive space requirements and consolidate program efforts when possible.

The entire Department of Space construct will be a more efficient process ensuring the warfighter and IC requirements are known, vetted, budgeted for and effectively met (see Department of Space S&T Chart below). More effective and cheaper ways of hardening satellites would be explored. Increased mobility in space, without the associated fuel costs would be developed. S&T initiatives would attempt to create new ways to predict solar storms and impacts on satellites and space systems. Improved and more efficient launch methods would also be developed. Labs would continue to exist in their current construct, however their efforts would be verified, consolidated when necessary, vetted and funded based upon priorities required. The Department of Space consolidation would allow such authority to exist where it currently does not.

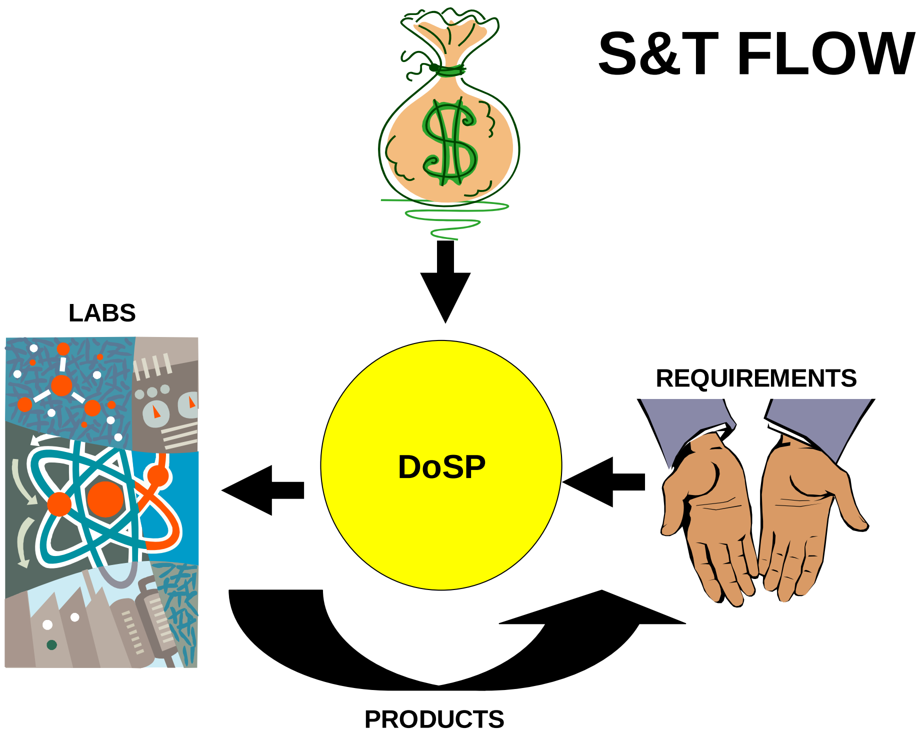

Figure 13 Department of Space Acquisition S&T Flow

Tier 3 Conclusion

While cost was considered for measuring the effectiveness of the Department of Space's assumption of responsibilities and resulting responsiveness, at least from plans and policy, acquisition and S&T/R&D perspectives, we decided it is not be the best measure of effectiveness. The best measures of effectiveness for Tier 3 include responsiveness, efficiency and flexibility. The consolidation of the Department of Space would result in more efficient communication between members of the space community and the development of space plans and policies that focus on responsiveness. The Department of Space will determine what standards are for timeliness and responsiveness. The Department of Space will develop more efficient acquisition processes that result in less waste and cost overruns and are focused on

responsiveness to military and intelligence requirements, and when necessary, respond faster than today's systems to national emergencies. The Department of Space will prevent duplication of efforts or lack of efforts for necessary S&T initiatives, unless those efforts are necessary and beneficial to users' requirements. This increased efficiency would probably result in lower costs in the long run, however, startup costs and consolidation costs could prove extremely expensive in the short term. It may take many years of efficient operation to re-coup the costs of reorganization.

Under Department of Space consolidation, Development Time and Technology Insertion Time, both subsets of the measure of effectiveness "responsiveness" would greatly improve. Under a Department of Space with a responsive mindset, the time necessary to develop responsive space technologies would decrease. Also under the Department of Space construct, technology insertion time would decrease with new space policies focused on responsiveness to warfighters' and intelligence professionals' needs. Additionally, improved communication flow, a controlled budget, and the elimination of duplication of efforts would all lend to a more efficient and focused construct than currently exists within the space community.

The Department of Space offices will ensure customers requirements are met as quickly as possible and will provide a conduit for users, labs and funding organizations to communicate freely and rapidly. By the consolidated nature of the Department of Space, all innovative or new space related technology developers will have one government organization to which they can present their ideas and prospective technologies. A collaborative virtual environment, listing program status and users' requirements, would make efforts within the Department of Space transparent to approved users and members of the commercial sector. The consolidation of efforts within the Department of Space, as well as the consolidation of funding for operationally

responsive space S&T projects would allow those programs to be prioritized and funded according to the most demanding national security requirements. The bottom line is that consolidation of efforts under the Department of Space will ensure more efficient processes in Tier 3, months to years, functions. The more efficient processes will prevent the duplication of efforts in technology initiatives that exist today. Funding for programs will be competitive and determined by real and prioritized needs. All members of the Department of Space will have insight into the programs being developed and will be able to comment and affect positive changes within those programs. These improvements in efficiency and operations will ultimately result in greater responsiveness for our users.

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VIII. SCENARIOS

We chose to evaluate four likely or critical scenarios and the ability of our architecture to be responsive. Following are the four scenarios.

- **Scenario 1**-Battlefield Space: Major conflict with a military peer. With ASATs targeting our critical satellites; our defensive counter space capabilities, redeployment capabilities and our quick launch capabilities will all be challenged.
- **Scenario 2**-Loss of UHF SATCOM
- **Scenario 3**-Major event not covered by satellite observation. This scenario does not elicit a space response.
- **Scenario 4**-Emerging technology developed for greatly increased communication throughput is a Tier 3 response.

<u>Scenario 1</u>

The battlefield space scenario is one that people envision when they cite our soft underbelly of space. Since we depend on space more than any other country in the world, and we have limited ability to protect our space assets: Space is our “Achilles Heel” (Crosier 19). This critical scenario must be addressed because of the severity of the consequences. It is thought that any battle with a near peer will target our satellites and ground stations first, to prevent the use of our space based assets in retaliation. In this scenario our responsiveness is most apparent. With our robust SSA we use predictive analysis to attempt to preserve the assets targeted. The targeted satellites will have offensive and defensive countermeasures that increase their survival rate. Satellite ground stations, and launch bases have robust missile defense systems that can thwart most attacks. If our defenses fail, our warfighters have trained in a denied environment, so the impact of lost assets is minimized. For any lost satellites we immediately take measures to recover the lost capacity. First, we will look to terrestrial means to recover the capacity in the short term. Second, we will augment our capacity in any other way we can, including purchasing commercial communications and IMINT. Third, we will begin

repositioning on orbit assets and start the launch sequence for spare satellites with spare launch vehicles on spare, flexible launch pads. Last, we will analyze our points of failure and begin development of assets that are more difficult to deny. This scenario shows responsive capabilities from each tier and is a strong advocate for the need of responsiveness in the form of the Department of Space.

Scenario 2

A more likely scenario is loss of a single satellite, like UHF SATCOM for example. This scenario could be brought on by: Enemy action, environment, or equipment malfunction. In each case the responsiveness is apparent. Our capable SSA system would alert us within minutes if we lost a satellite. Ops centers would inform their users in near-real-time and work on replacing that capability, by purchasing commercial bandwidth or using terrestrial means. The users would be trained to execute pre-planned responses and operate without UHF SATCOM. If a satellite was lost, a spare satellite would be launched quickly. The robust SSA would let us know why we lost the satellite and we would begin developing technologies that could prevent future losses of satellite capability.

Scenario 3

Another likely scenario is a major event, like a foreign weapons test, timed specifically so that there are no US national space assets available to observe it. This scenario does not elicit a space response. Terrestrial assets may be used to observe, but our responsive space program does not have ready or expendable satellites for this scenario.

Scenario 4

A startup company has developed a new disruptive space technology. They are unsure who within the space community could best benefit from their new or improved process or system. Under the Department of Space construct, those individuals would intuitively know they have to contact someone within the Department of Space to sell their technology. Through the Department of Space / S&T virtual collaborative environment, they would find out whether their idea is truly a novel idea or new approach. They would learn of potential user requirements they could satisfy. They could request funding from within the Department of Space to further refine their research. If the Department of Space determined that their technology was mature enough and relevant enough to current space operations, the startup company would be invited to attend and demonstrate their product at the yearly space symposium for responsive space. Their product, once deemed relevant and worth consideration within the FY S&T funding budget, could be further refined or if ready, entered into the responsive space acquisition process. If there happened to be a Priority I effort for national security taking place, their new space technology could immediately receive manpower, resources and funding. If not a priority I effort, they would be directed to the appropriate acquisition process. Prior to entering into production, the new technology would be matched to customer requirements, vetted, prioritized and funded if deemed worthwhile.

This entire process would be more responsive than the system as it exists today. Centralized control of the acquisition processes and S&T research funding, would ensure the new technology would be directed, in as quick and efficient process as possible, toward the appropriate user's requirement.

The Dept of Space will be more responsive than today's National Security Space Enterprise through:

- Implementation of new policies and directives focused on responsiveness,
- Changes within the acquisition process that enforce new standards and timeliness requirements
- A new construct of the R&D and S&T community with the Department of Space in the center determining requirements, funding and which labs will do the work.

The way in which a new technology is introduced and developed in the future, under the Department of Space, will be more responsive due to the Tier 3 changes mentioned above.

IX. WITHOUT A DEPARTMENT OF SPACE

The Department of Space is a huge catalyst for implementing most of our changes to be more responsive. If we are unable to stand up the Department of Space, however, many of our recommended improvements to provide more responsive space to the warfighter and intelligence community are still possible.

<u>Tier 1 Improvements Without a Department of Space</u>

There are steps to improve Tier 1 responsiveness, even without the creation of a Department of Space. Specific improvements that can be made without the creation of a new department are:

- The JSPOC could be manned to provide the recommended situational and operational awareness that would enhance response time.
- All DoD and IC space constellation mangers could be directed to provide the near-real time situational and operational updates to the JSpOC.
- Space-product customers could work with the JSpOC to report and request changes to, or losses of capability and capacity.
- The JSpOC could be the central authority for space products, while the analysis centers would continue to assess and report on the products obtained.
- The JSpOC could work with individual database managers to ensure obtained space products are added to the various databases.
- The JSpOC could monitor commercial and non-space solutions, so that if DOD/IC space products are not available, requests can still be met in the Tier 1 response time frame.

The JSPOC is in the ideal situation to improve our Tier 1 response times. It currently has visibility of most commercial and national systems, but is not empowered to force responsiveness. The JSpOC is also not manned or funded to meet Tier 1 response times. With appropriate manning, improved connectivity and consolidation of appropriate SMEs, the JSpOC could achieve Tier 1 requirements.

There are areas of SSA and Counter Space changes that can be implemented without the formation of the Department of Space. First, and most essential, would be to provide Joint Functional Component Command (JFCC) Space additional manning and statutory measures to empower this organization to actually give the Government an SSA near-real time picture. The Joint Billets at JFCC Space current manning and operations are significantly below the necessary level to effect any change in space with only seven of twenty-eight billets filled (Santee 12). Getting the SSA and CS into the decision making process within the JSpOC or the DoD is a cultural change that will not be easy, but fundamentally could be accomplished without the Department of Space. In light of the highly classified world of Counter Space, an effect that could be readily felt is to have a Counter Space representative at the larger space commands. This representative would help facilitate the Commander's decision on what and how to do things with the tools Counter Space brings to the table. None of these changes will be free, there will be a large up front cost, but if responsive change is going to happen, then these are needed. The face-to-face relationships needed for these changes are indispensable.

Without a Department of Space, several of the training initiatives for Tier 1 could still be implemented. It has already been acknowledged that the training budget will be hard to quantify because it is not usually a specific line item, and the assumption has been made that it will be a small amount when compared to the Department of Space budget supposed in this architecture study. Specifically, the web-based training and wiki for collaboration were implemented because of their accessibility and ubiquity for a small dollar amount, and they would be appropriate measures to institute. Also, providing individuals for training exercises to ensure training in a denied environment is accomplished and to record and process the associated metrics could be implemented without the Department of Space framework. Finally, a certain

level of training could be done at individual Operation Centers throughout the NSSE, but it could only be accomplished in a limited capacity because of the personnel costs involved and the lack of a centralized command structure. Essentially, the 14^{th} Air Force could institute a training initiative, but the NRO entities would not have to recognize it or conform. For the most part, the training initiatives could be implemented with small up-front costs and theoretically should yield positive results.

<u>Tier 2 Improvements Without a Department of Space</u>

Many of the changes recommended in the Tier 2 area require the creation of a Department of Space as a catalyst for that change; ALL of the changes are at least helped by the existence of a Department of Space. Some of our changes; however, could be done without a Department of Space. The mandatory spare policy for our Group 1 and 2 satellites, for example, could be done with the right priority within the Air Force. At a cost of \$300-500M per satellite, though, it is unlikely to ever get funded over other programs. The spare launch vehicle, on the other hand, really is not a "spare" but rather just buying the next vehicle early. That could be done by reprogramming funds from one Fiscal Year to another. It would put a pinch on the current year, but other programs could be pushed out to make it happen. Flexible launch pads and facilities could be done, but at a high cost; it is in fact already being done by the commercial spaceports at the Cape and Vandenberg. Each pad would likely cost \$500M for renovation plus engineering design of the changes. It probably would not get the support it needed for funding within the Air Force, given the "If it ain't broke…" mentality. Centralizing site management of the Federal launch sites is a non-starter without the Department of Space. As long as NASA, the NRO and the Air Force all serve different masters and different priorities, there is really no way to centralize the facilities and bases that serve all three. A common bus architecture for research

and development is possible without a Department of Space, but it needs to be managed by an NSSE wide Science and Technology organization. Flexible launch crews that are capable and trained to process multiple types of launch vehicles are certainly possible without a Department of Space. If the government announces the change far enough in advance and sets a cutover date, they would simply hire the current Boeing/Lockheed launch teams to man the new contracts and then train them across a variety of platforms. Finally, improving commercial business at the Federal launch sites is also tenable without a Department of Space. Financial incentives and management can be done today with the right government intervention. While some pieces of the Tier 2 efforts could be made more responsive without a Department of Space, the ones with the greatest impact are impossible without the funding and prioritization that a Cabinet-level organization can bring to the table.

Tier 3 Improvements Without a Department of Space

Even if a major reorganization of US National Space systems into a department of space were not possible at one time, there are small steps that could be taken now to improve efficiency, timeliness and responsiveness of our national Tier 3 functions.

The 2001 Space Commission Report concluded that:

> "Currently, there is no DoD appropriation that identifies and aggregates funding for space programs. Space funding is a part of many appropriations spread across the DoD and Intelligence Community Budgets… These multiple appropriations lead to several problems. When satellite programs are funded in one budget and terminals in another, the decentralized arrangement can result in program disconnects and duplication. It can result in lack of synchronization in the acquisition o of satellites and their associated terminals. It can also be difficult for user requirements to be incorporated into the satellite system if the organization funding the system does not agree with and support those user requirements. The current methods of budgeting for national security space programs lack the visibility and accountability essential to developing a coherent program."

Certainly the solution for the above problem is clear. One organization responsible for both acquisition and development of our national strategic space systems is required. Additionally, the disconnect between user requirements and requirements of the funding agency can cause a system to be developed and built that works perfectly as designed, but does not meet the needs of the customer.

The natural solution to this problem would be for form a consolidated national space S&T organization, (which would become the Department of Space S&T division when the Department of Space is formed). This agency would be responsible for development and acquisition of all national DoD, IC, and research space systems. Many of the benefits previously mentioned for a consolidated Department of Space S&T division could be realized with such an organization.

Acquisition is another area where improvements could be made, even short of formation of a Department of Space. Current acquisition programs and processes could be examined, and inefficiencies identified to promote more cost effective and timely acquisition of space systems. Additionally, there is no acquisition process that is equipped to rapidly insert new disruptive technology into space, or capable of replacing an on orbit asset in a short timeframe. Even if such a process were built, and funding were available, there is no efficient way to bring experts and other critical personnel in at very short notice to work on a high priority projects (even if just temporarily) to rapidly develop and build a new critical space systems. Of course if a Department of Space existed, it would have the authority to reallocate personnel working on other lower priority projects temporarily to the critical project. Therefore some type of arrangement must be made with NASA, government contractors (such as Boeing and Lockheed Martin) and others space development experts to allow the government acquisition community to obtain their

services immediately (even if this means delaying other space programs of lower priority) to develop and build urgent and critical space systems in a national emergency or other situation deemed important and urgent enough to merit this unusual, expensive, yet rapid acquisition process. In addition to funding and space system experts, expensive machinery (such as thermal vacuum chambers, shaker tables, and EMI testing facilities, and manufacturing facilities) would need to be immediately available for use in order to built urgent priority I space systems. There are two ways to solve this problem. The first would require the government S&T community to maintain government owned testing and manufacturing facilities on standby to develop, build, and test an urgent, high priority space system. This option would be extraordinarily expensive, since these facilities would be mostly un-used. Additionally, it would be difficult to determine whether the facilities built could be adequate for all types of space systems since satellites vary greatly in size and complexity. The second option (and probably more reasonable of the two) would be to pre-arrange contracts with current government and DoD contractors who already own facilities necessary to develop, build and test space systems to allow immediate use of these facilities by the government for an urgent, high priority space system. Since the use of these facilities at short notice would almost certainly delay other projects already in progress by the contractor, the contracted rate would probably be much higher than normal. This option would also allow the government more flexibility since large contractors generally own facilities necessary to build everything from small to very large space systems.

The third thing could be done immediately to increase responsiveness in the US space S&T community. It would be to build an online virtual collaborative environment (VCE). An online VCE would allow everyone from government acquisition, scientists, government contractors and engineers to quickly and effectively collaborate online about problems and

solutions on government space related programs. Many of the benefits of office co-location could be enjoyed virtually on the VCE even though offices would not actually be co-located. Access to the VCE would only be allowed to verified members (i.e. contractors, Government employees, etc) to prevent misuse; Classified programs could be included on a VCE for Secret and Top Secret programs via the SIPRNET and JWICS to promote collaboration and improve communication efficiency. In addition to improved collaboration, it would dramatically increase transparency (especially for unclassified programs). It is difficult to know exactly how often two separate universities, contractors, or government labs are working on a solution to the exact same problem, or on a problem that has already been solved by someone else at another lab. Such VCEs are already in use and have become extremely beneficial to some of the most efficient development companies in the world such as Google, Microsoft and Apple, and could be equally beneficial to government space acquisition and development.

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X. CONCLUSION

To provide responsive space by 2025 we must make sweeping changes to the NSSE. All of these changes are not possible unless we consolidate our space organizations into one single organization. We propose the Department of Space to be that organization. At the cabinet level, it will have the required clout to get the funding required. It will unite the community and allow one consistent vision, one set of policies, and one culture. Having a responsive culture under one organization will prove to be the largest catalyst to making space as responsive as it can be. In this environment, we will implement responsive policies that will enable better and quicker space-related services to our customers.

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LIST OF ACRONYMS

ACQ	Acquisition
AFB	Air Force Base
AFS	Air Force Station
ASAT	Anti-Satellite
CCAFS	Cape Canaveral Air Force Station
CIA	Central Intelligence Agency
COMINT	Communications Intelligence
Comm	Communications
DARPA	Defense Advanced Research Projects Agency
DCS	Defensive Counter Space
DIA	Defense Intelligence Agency
DNI	Director of National Intelligence
DoD	Department of Defense
DoNSp	Department of National Space Operations
DoSp	Department of Space
EELV	Evolved Expendable Launch Vehicle
ELINT	Electronic Intelligence
EMCON	Emissions Control
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
FAA	Federal Aviation Administration
FY	Fiscal Year
GAO	Government Accounting Office
GEO	Geosynchronous Orbit
GIG	Global Information Grid
GPS	Global Positioning System
HALL	High Altitude Long Loiter
HEO	Highly Elliptical Orbit
HQ	Headquarters
IC	Intelligence Community
ICBM	Intercontinental Ballistic Missile
IMINT	Image Intelligence
ISR	Intelligence Surveillance Reconnaissance
JCIDS	Joint Capabilities Integration Development System
JFCC	Joint Functional Component Command
JP	Joint Publication
JROC	Joint Requirements Oversight Council
JSpOC	Joint Space Operations Center
JWICS	Joint Worldwide Intelligence Communications System
KC	Knowledge Center

LC	Launch Complex
LCDR	Lieutenant Commander
LEO	Low Earth Orbit
LPI/LPD	Low Probability of Detection/Low Probability of Intercept
LSD	Launch Support Division
LT	Lieutenant
Maj/MAJ	Major
MDA	Missile Defense Agency
MEO	Medium Earth Orbit
MoE	Measure of Effectiveness
NASA	National Aeronautics and Space Administration
NDB	National Database
NGA	National Geospatial Intelligence Agency
NOAA	National Oceanographic and Atmospheric Administration
NRO	National Reconnaissance
NSA	National Security Agency
NSSE	National Security Space Enterprise
O&M	Operation and Maintenance
OA	Operational Awareness
OCS	Offensive Counter Space
OPS	Operations or Operations Center
ORS	Operationally Responsive Space
OSD	Office of the Secretary of Defense
PME	Professional Military Education
PNT	Positioning Navigation Timing
PPR	Pre-Planned Response
R&D	Research and Development
RSC	Responsive Space Conference
RSS	Rich Site Summary
S&T	Science and Technology
SA	Situational Awareness
SATCOM	Satellite Communications
SCIF	Sensitive Compartmented Information Facility
SCOE	Space Center of Excellence
SECDEF	Secretary of Defense
SECSPACE	Secretary of the Department of Space
SES	Senior Executive Service
SIGINT	Signals Intelligence
SIPRNET	Secret Internet Protocol Router Network
SLC	Space Launch Complex
SME	Subject Matter Experts
SpOCC	Space Operations Command Center
SSA	Space Situational Awareness
STK	Satellite Tool Kit
TacSat	Tactical Satellite

TAD	Temporary Additional Duty
UAS	Unmanned Aerial System
UHF	Ultra High Frequency
ULA	United Launch Alliance
VCE	Virtual Collaborative Environment
Wx	Weather

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